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FARM AND HOME CANNING OF PHILIPPINE FRUITS AND VEGETABLES

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NINE PLATES

Canning is the preservation of foods by means of heat in hermetically sealed containers. It is the commercially and most widely used means of preserving perishable fruits, vegetables and other food products.

Spallanzani in 1765 was the first to demonstrate the possibility of the preservation of food in sealed containers by means of heat. But the art of canning was discovered by Nicholas Appert of France in 1804, and in 1810, he received 12,000 francs from the French Government for a method of preserving food for Napoleon's troops. His methods, which have been modified and improved upon, are the basis of modern canning practices.

In 1810, Peter Durand, an Englishman, secured a patent covering the preservation of all perishable foods in containers of glass, pottery, tin and other suitable metals. The method was practically the same as that of Appert, from whom he had obtained his knowledge.

The tin can being light and non-breakable, very early became the container for commercial canning. The first tin cans used were made by soldering the bodies and ends. The modern or

sanitary can was developed by Charles M. Ams in the early nineties. He also developed the sealing compound that is applied on the covers to give the hermetic seal. With the invention of modern machinery for hermetically sealing the covers to the body, the sanitary or open top can came into general use.

VALUE OF CANNING AND ITS POSSIBILITIES IN THE PHILIPPINES ISLANDS

There are many reasons why canning should be a profitable undertaking on the farms and in the homes:

1. Large quantities of food materials can be saved which would otherwise be spoiled and go to waste or be marketed at a loss.
2. Canning provides the home with a large supply of foods throughout the year and therefore allows a greater variety in the diet, thereby giving better nourishment to the body.
3. A large amount of labor is saved in the preparation of meals if an adequate supply of canned foods is available.
4. Canning the surplus raw products when they are cheap will result in considerable saving in the item of food expense.
5. Canning will give pleasant and profitable employment to many people and enables the farmer to start a business, in a small way, which may be developed into a profitable investment. Occasionally, the home or farm factory develops into one of commercial size.
6. If canning is popularized, the growing of more fruit trees and vegetables will be greatly stimulated.

These reasons and the fact that a large quantity of canned fruits and vegetables are annually imported into the Philippine Islands (see Table 1) show the great possibilities for the canning of fruits and vegetables here.

If we can only produce canned fruits and vegetables for local consumption, not to mention the possibilities of exporting some of them, it will be sufficient reason to justify the widespread dissemination of the knowledge of canning.

It is therefore the purpose of this paper to describe briefly the principles, methods, and other important points of the art and science of canning to enable farmers, farm-wives and others who may be interested in the subject to undertake the canning of Philippine fruits and vegetables on the farms and in the homes.

After one has obtained some experience, he will soon find the need of more exhaustive and detailed references, a list of which is given at the end of this paper.

GENERAL PRINCIPLES INVOLVED IN CANNING

Foods spoil through the activity of one or more of the following groups of living organisms or spoilage agents: molds, yeasts, bacteria, enzymes.

Under proper conditions of temperature and air supply, the agents attack certain constituents of the food and convert them into compounds which render the food objectionable or, and, in many cases, unfit for human consumption.

Molds, which are exemplified by the bread mold, are familiar to everyone, since they are visible to the naked eyes. Molds grow readily in all kinds of foods, provided suitable moisture and temperature conditions prevail. Molds are easily killed by heating the food for a few minutes at boiling temperature or by prolonged heating at a temperature below the boiling point of water.

Yeasts are microscopic in size and are responsible for the fermentation of saccharine foods, particularly ripe fruits and some vegetables.

One of the products of fermentation is a gas called carbon dioxide, which causes the swelling of tin cans. Swelling is one of the signs of spoilage. Yeasts, being less resistant to high temperature than are some of the molds, are readily killed by heating.

Bacteria causes the spoilage mainly of non-acid foods. Bacteria are much more resistant to heat than either mold or yeast and their destruction is therefore more difficult. They grow best in a non-acid medium, but readily succumb to heat in the presence of acids. Many bacteria exist in two forms—the growing or vegetative and the resting or spore form. Practically all living bacteria are killed at the temperature of boiling water (100°C.) if prolonged for a few minutes, but the spores of some species can resist the action of boiling water for many hours. Some bacteria produce substances called "toxins" which are deadly poisonous. Unfortunately the presence of the most deadly bacteria, that known as *Bacillus botulinus* is not detected by visual observation. The only safeguard against the possible presence of botulinus is to boil canned foods, particularly vege-

tables in open vessels for several minutes. The heat destroys the poisonous substances, and thereby renders the foods safe to eat.

Enzymes are substances which induce chemical changes in foods. They occur naturally in all organic materials. They are soluble in water and are more effective at from 27°C. to 43°C. Heating at 100°C. for a short time makes them inactive. Because of the comparatively lower temperatures used in processing them, canned fruits are particularly subject to enzyme action.

The most noticeable effect of enzyme action on canned foods is the change in color. The food first turns brown and if action continues for some time finally black.

STERILIZATION

Sterilization or processing of canned fruits and vegetables is accomplished by means of heat. Besides rendering inactive or destroying all organisms and enzymes in foods, heat often makes food more nutritious and palatable. There are four general methods of sterilizing food by heat after it has been packed into the containers: (*a*) the one period method, (*b*) the fractional or intermittent method, (*c*) the steam pressure method, and (*d*) pasteurization method.

A brief description of each of these methods is given as follows:

(*a*) *The one-period method* consists in subjecting sealed or partially sealed packages of food to a single period of heating either in steam or hot water at the boiling point of water. The length of the period is determined by the nature of the food, the solidity of the pack and the size of the container. This method is the one most commonly recommended for sterilizing canned fruits.

(*b*) *The fractional or intermittent method* is more generally used for non-acid foods such as meats and vegetables where a pressure cooker is not available. The prepared foods are packed into the containers and are then subjected to a relatively short processing at the temperature of boiling water for three successive days. The object of this method of sterilization is to insure the destruction of all spoilage organisms and spores of certain forms of bacteria. The first day sterilization may not destroy the spore form. But when this spore form is changed to the growing or vegetative form, the latter is more easily killed by heat. The objection to this method of processing is that it is

expensive and troublesome besides subjecting the foods to a prolonged heating, thus affecting somewhat the taste and consistency of the sterilized food.

(*c*) *The steam-pressure method* is used in the commercial canning of most vegetables, meats and sea foods. The prepared foods are packed into the containers, and the containers are then placed in a pressure cooker, where the temperature can be raised far above the boiling point of water. The temperatures most commonly used are 240°F. (115.6°C.) and 250°F. (121°C.). Foods processed in this way will show a minimum amount of spoilage.

(*d*) *Pasteurization* is used for milk and fruit juices where boiling affects the flavor and taste of the product. Pasteurizing temperature ranges from 156° to 170°F (69° to 78°C.) The juice or milk is poured into the containers, which are then put into a water bath where the temperature is maintained at from 69° to 77° for from 20 to 30 minutes.

EQUIPMENT AND UTENSILS

The equipment necessary for home or farm canning are determined by the kind and amount of products that are handled. Gas, steam or other cheap sources of heat supply can be used.

The operator of a large home factory may prefer to install a small boiler of 10 to 15 H. P. from which steam under pressure may be taken for heating the processers, blanching water, and other heating appliances and equipment. All processing and cooking operations are shortened by the use of steam under pressure. Steam-jacketed kettles and steam coils whenever their use will entail no great additional expense may be used for all cooking operations. The installation of equipment for the use of steam is expensive but where production is large the saving in time and effort will justify it.

For sterilizing canned fruits, open cookers or water baths would be sufficient. They can either be heated by a steam coil or directly by gas. A pressure cooker is essential for processing vegetables and other foods such as meat, fish, etc. Pressure cookers can be heated directly with gas or by means of steam whenever available. There are various types of pressure cookers, viz: the vertical, horizontal, rotary and continuous pressure cookers. All of these cookers are now being used in commercial plants, but for a small farm, a medium-sized vertical cooker will be satisfactory.

For containers, tin cans are used. For sealing the covers of the cans to the body a sealing or closing machine is necessary. Tin cans can be bought in the United States or from some big packing companies in the Philippines. Those who would use a large quantity of tin cans would find it profitable to import the can bodies in the "knock-out" or "collapsed" condition and reform them here upon arrival. In this way, much expense would be saved on freight, as more tin cans could be packed to a case. For collapsed cans, a can reforming machinery is necessary. If the demand for sanitary cans was large, the establishment of a can-making factory might be found profitable. Already there are some companies in the city which can manufacture sanitary cans.

Closing machines range from the ordinary hand-sealing machine to the automatic vacuum closing machine that can seal at the rate of 100 a minute. For farm or home use, a simple and cheap hand-sealing machine will be sufficient. The operation of the hand sealer is very simple but the big automatic machines require skill and experience.

Besides this equipment, utensils such as different kinds of hydrometers, porcelain basins, pails, dishpans, kettles, stainless knives and other kitchen utensils are needed.

Photographs of some of the equipment and utensils needed for canning are given at the end of this paper.

MATERIALS AND METHODS

Fruits are usually canned in syrup to improve the taste and flavor. Sour fruits require a heavier syrup than sweet fruits. In general syrup of from 20 to 70 per cent concentration are needed for Philippine fruits. In preparing large quantities of syrup, the use of Brix hydrometers, which give the reading in per cent of sugar in the syrup, is recommended.

Refined cane sugar is used in preparing syrups. A weighed amount of sugar or a measured quantity in cups is dissolved in a given volume of clean, pure water with the aid of heat and then strained through a piece of fine cheesecloth. A saturated solution of sugar can be made and the desired concentrations of syrup prepared from this saturated solution by dilution and checking the required concentration by means of a Brix hydrometer.

Table 3 gives directions for preparing syrups of different concentrations.

Vegetables are usually canned in brine to improve the taste and flavor. Good quality salt is necessary but for ordinary purposes the native salt will do. The brine solution should be filtered through a piece of fine cheesecloth to remove impurities and objectionable sediment. A salometer hydrometer gives the strength of the brine. The reading of the instrument divided by 4 gives the approximate per cent of salt in the brine.

Table 4 gives the directions for preparing brine used in canning and pickling vegetables.

SELECTION OF FRUITS OR VEGETABLES

Well ripened, fully matured fruits are best for canning. Unripe fruit is low in quality, hard in texture, too acid in taste, and lacks the natural flavor and aroma of ripe fruit. On the other hand, over-ripe fruits will crush easily and will not give an attractive looking pack. Soft and over-ripe fruits should be discarded and saved for use in the preparation of jams, butter, pastes, fruit juices, wines or vinegar.

SORTING AND GRADING

The first operation in the canning of fruits is the sorting, or selection of sound fruits, free from blemishes and rots. After the preliminary sorting operation, the fruits are graded for size, color and ripeness. Ungraded canned fruits are unattractive in appearance, uneven in color, texture, and difficult to work.

WASHING AND PEELING

The graded fruits are then washed thoroughly and peeled, preferably with stainless knives. The pits or seeds are removed, and the fruit pulp cut or sliced to the desired sizes and shape. The sliced fruits are then ready for packing into the cans.

BLANCHING

Vegetables should also be sorted and graded in order to obtain a uniform, good quality pack. Most vegetables are first blanched before filling into containers. Blanching consists in soaking the vegetables in boiling water or steam for 2 to 3 minutes, followed by cooling in a tank or spray of cold water. Then the blanched vegetables are filled into the cans.

SYRUPING, BRINING AND ACIDIFYING

A hot syrup (for fruits) or brine (for vegetables) is added to the filled cans. It is recommended that non-acid vegetables be

acidified with a teaspoon of fresh lemon or lime juice to aid in the sterilization of the product. Non-acid vegetables are very susceptible to infection by botulinus spores, which in turn develop a toxin inside the container that may cause the poisoning of persons eating the botulinus-infected canned vegetables which have not been properly sterilized. It is also strongly advised that canned vegetables be boiled for at least 10 minutes before eating. The addition of an acid like lemon or lime juice aids greatly in the destruction of botulinus organisms in canned foods.

EXHAUSTING OR VACUUMIZING

The filled cans are then heated in a water bath until the temperature of the center of the contents is at least 70°C. This takes from 5 to 15 minutes. The object of exhausting is to drive out all cold air inside the container so as to create a vacuum after the can has been sealed, sterilized and allowed to cool. The production of the vacuum inside the can minimizes corrosion of the tin plate inside the can, prevents undue strains in the can during processing, and keeps the ends of the cans from bulging out.

SEALING

The cans are immediately closed after exhausting. Sanitary cans are closed by double seaming machines which range from an ordinary hand-operated, double seamer to the highly complicated automatic vacuum closing or sealing machine that can seal cans at the rate of 100 a minute. The closing or sealing process consists of two operations. The first rolls the edge of the cover and the flange of the can into a tight roll, and the second tightens and smooths this roll against the side of the can. The heat of the can and its contents causes the sealing compound to flow into any unfilled space and thus makes a perfect hermetic seal.

PROCESSING

Processing or "sterilization" is the most important operation in the canning of foods. Processing should be thorough enough to sterilize the contents, but not prolonged so unduly as to injure the texture and flavor of the product. Under-processing or insufficient sterilization is one of the principal causes of spoilage.

Fruits are usually processed in open cookers either in water or steam at a temperature of 100°C. The natural acidity of fruits aids greatly in the sterilization or processing. For most Philippine fruits sterilization for from 20 to 30 minutes at 100°C. is sufficient for the No. 2 cans. Table 5 gives the length of exhaust and process for different Philippine fruits which have been tried.

Non-acid vegetables are usually processed in closed pressure cookers at 240°F. to 250°F., or at 10 to 15-pounds pressure. Because of their acid character, some vegetables like tomatoes are sterilized in open cookers. Table 6 gives the length of exhaust and process for some Philippine vegetables.

COOLING

After processing cans should be cooled immediately in tanks of cold running water, or by sprays of cold water. Cooling is important in order to prevent overcooking of the product. Cooling, if done correctly, preserves the texture, color and flavor of the fruit or vegetable.

STORING

After cooling, the cans are placed in a cool, well ventilated place. They should never be put into damp warehouses lest the cans rust. Rusting can be greatly lessened by varnishing the outside of the can with air-drying lacquers. This is particularly advisable in tropical countries. Several kinds of these lacquers are now sold in the market. Cans which are lacquered or enameled inside are used for certain fruits or vegetables which readily attack plain tin cans.

TESTING

One day after processing, cans should be examined for leaks by tapping the end of the can with a piece of iron or nail. A well sealed can will give a full solid sound while a leaky can gives an empty ringing sound. Defective cans should be separated from the good ones immediately.

LABELING

Cans are labeled before they are distributed or stored away. It is always a good practice to note when the foods were canned

in order to determine the age of the canned product at the time a can is opened.

When the canned goods are to be sold, they should be labeled properly and attractively in order to add to the salability of the finished product.

REFERENCES

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3. CRUESS, W. V., 1924. Commercial Fruit and Vegetable Products. McGraw Hill Book Co., Inc., 370 Seventh Ave., New York City. 530 pp., 100 figs.
4. CRUESS, W. V., 1925. Home and Farm Food Preservation. The McMillan Co., New York City. 270 pp., 56 figs.
5. CHENOWETH, W. W., 1930. Food Preservation. John Wiley and Sons, New York City. 344 pp., 76 figs.
6. MALCOLM, OLA POWELL., 1930. Successful Canning and Preserving. J. Lippincot Co., Philadelphia. 663 pp.

The following journals will be found very valuable by those interested in canning and other food industries:

1. *The Canner*, published by the Canner Publishing Co., 140 N. Dearborn St., Chicago, Illinois.
2. *The Canning Age*, published by Canning Age Publishing Co., New York City, New York.
3. *The Canning Trade*, published by the Canning Trade Publishing Co., Baltimore, Maryland.
4. *Food Industries*, published by McGraw Hill Publishing Co., New York City, New York.
5. *Fruit Products Journal and American Vinegar Industry*, published by Avi Publishing Co., New York City, New York.

TABLE 1.—*Annual and 5-year average importation of canned food products of the Philippine Islands for 1927–1931*

[Prepared by the Statistics Section, Bureau of Plant Industry, Manila]

Articles	Quantities					
	1931	1930	1929	1928	1927	5-year average
Meat and dairy products:						
Meat products—						
Canned—	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*
Beef	484,547	509,735	780,972	533,792	620,471	585,903
Pork	72,527	41,874	47,445	85,907	111,022	71,755
Sausage	134,744	110,833	192,604	240,990	226,435	181,121
Soup	64,064	29,620	76,039	66,656	32,822	53,840
All other canned meat	113,699	73,046	76,534	127,930	110,052	100,252
Dairy products—						
Butter—Canned	143,303	180,700	181,955	194,928	171,939	174,565
Milk—						
Condensed	4,307,943	4,140,990	4,314,220	3,727,079	3,869,777	4,072,002
Evaporated	11,682,780	9,048,105	9,236,867	8,303,966	7,911,901	9,236,724
	Liters	*Liters*	*Liters*	*Liters*	*Liters*	*Liters*
Natural	1,028,239	956,082	1,231,837	1,130,700	926,312	1,054,634
Fish and fish products:						
Canned—	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*
Mackerel	185,683	1,224,923	.....	.....	.....	282,121
Salmon	1,163,561	562,782	317,050	1,163,005	3,158,193	1,272,918
Sardines	4,520,328	8,577,880	9,500,438	6,240,331	8,222,141	7,412,224
Shellfish	230,873	154,651	219,187	89,228	180,254	174,839
All other canned fish and fish canned products	911,394	2,182,184	2,750,981	2,783,276	205,930	1,766,753
Vegetables:						
Canned—						
Beans	211,421	271,649	205,263	329,156	307,196	264,937
Peas	519,396	470,068	398,402	461,196	424,267	454,666
Tomatoes	327,993	716,626	403,782	524,447	752,742	545,118
All other	796,963	862,107	954,459	954,262	868,248	887,208
Fruits and nuts:						
Canned—						
Pineapples	341,794	262,463	302,617	323,534	252,476	296,577
All other	681,296	689,173	751,758	869,797	613,210	721,047

TABLE 1.—*Annual and 5-year average importation of canned food products of the Philippine Islands for 1927–1931*—Ctd.

Articles	Values					
	1931	1930	1929	1928	1927	5-year average
Meat and dairy products:						
Meat products—						
Canned—						
	Pesos	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*
Beef	(691,758)	(614,510)	(913,090)	(1,002,518)	(902,181)	(822,812)
Pork	304,683	325,804	489,005	419,599	391,560	386,130
Sausage	100,221	69,449	69,025	103,721	124,248	93,333
Soup	152,284	135,232	244,826	331,280	277,617	228,248
All other canned meat	35,568	23,951	43,561	36,071	21,568	32,144
Dairy products—	89,002	60,074	66,673	111,847	87,188	82,957
Butter—Canned						
Milk—	227,235	323,512	356,789	385,893	344,076	327,501
Condensed	(6,673,095)	(5,859,654)	(6,199,851)	(5,921,161)	(5,473,535)	(6,025,460)
Evaporated	2,356,344	2,259,279	2,296,420	2,143,462	2,161,459	2,243,393
Natural	3,989,898	3,265,284	3,507,415	3,396,525	2,978,982	3,427,621
Fish and fish products:	326,853	335,091	396,016	381,174	333,094	354,446
Canned—						
Mackerel	(1,858,274)	(3,475,877)	(3,817,898)	(3,405,200)	(3,799,899)	(3,271,430)
Salmon	35,674	357,093				78,553
Sardines	310,281	216,994	109,909	495,125	1,145,911	455,644
Shellfish	1,157,600	2,201,893	2,680,366	1,803,945	2,427,540	2,054,269
All other canned fish and fish canned products	127,983	97,751	137,333	66,493	121,524	110,217
	226,736	602,146	890,290	1,039,637	104,924	572,747
Vegetables:						
Canned—						
Beans	(577,469)	(715,072)	(688,200)	(762,704)	(714,499)	(691,490)
Peas	76,528	104,569	82,489	114,417	94,874	94,577
Tomatoes	147,457	130,685	117,211	134,374	114,528	128,851
All other	61,245	152,990	96,238	124,185	170,572	121,046
	292,239	326,828	392,262	389,728	334,525	347,116
Fruits and nuts:						
Canned—						
Pineapples	(332,720)	(362,719)	(435,860)	(457,265)	(337,043)	(385,122)
All other	84,538	83,689	103,811	98,297	74,718	89,011
	248,182	279,030	332,049	358,968	262,325	296,111
Grand total	10,350,551	11,351,344	12,411,688	11,934,741	11,571,233	11,523,915

TABLE 2.—*Number, size and capacity of standard sanitary cans for fruits and vegetables*

[After Cruess and Christie's "Laboratory Manual of Fruit and Vegetable Products"]

Number of tin can	Diameter in—		Height in—		Capacity in—	
	Inches	Cms.	Inches	Cms.	Fluid ounces	Grams
1 (Eastern Oyster)	2 1/16	6.80	4	10.16	11.6	329
1 (Tall California)	2 1/16	6.80	4 1/2	10.80	12.3	349
1 (Flat California)	3	7.62	2 3/8	6.03	16.0	454
2	3 3/8	8.57	4 1/2	11.43	21.0	596
2 1/2	4	10.16	4 1/4	12.06	31.0	880
2	4 1/4	10.8	4 7/8	12.38	35.0	993
10	6 1/8	15.61	7	17.78	107.0	3,038
12	6 1/8	15.61	8 3/4	22.22	128.0	3,634

1 inch=2.54 centimeters
1 fluid ounce=28.35 grams

TABLE 3.—*Showing the preparation of syrup of different concentration and their use*

Per cent sugar	Brix or Balling degrees	Weight of sugar in grams per liter	Cups[1] of sugar per liter	Consistency and use
20	20	200	1	Thin syrup for sweet fruits.
30	30	300	1 3/4	Medium thick for medium sweet.
40	40	400	2 1/4	Medium thick for slightly sour fruits.
50	50	500	2 3/4	Thick for sour fruits.
60	60	600	3 1/4	Very thick for very sour fruits.
70	70	700	3 3/4	Do.

[1] This cup is the standard kitchen measuring cup which contains 233 cc. water and approximately 188.0 grams sugar when full.

TABLE 4.—*Showing the preparation of brine from rock salt and their uses*

Salometer degrees	Per cent salt	Tablespoonful salt per liter	Grams salt per liter[1]	Use
10	2.5	4	25	Canning of vegetables.
20	5	8	50	Fermentation of dill pickles.
40	10	16	100	Pickling of vegetables.
60	15	24	150	Storage of fermented vegetables.
80	20	32	200	Stops fermentation.
100	25	40	250	Saturated solution.

[1] A tablespoonful of rock salt weighs approximately 10 grams.

TABLE 5.—*Time table for canning some Philippine fruits* [1]

Name of fruits	Concentration of syrup degrees Brix	Exhaust for No. 2 cans		Process in minutes
		Temperature	Minutes	100 °C.
	° *Brix.* [2]	°C.		
Guava	60	80	10	25
Lemasa	65	75	15	30
Mango sliced	50	70	10	20
Macapuno	65	75	10	30
Nangka	65	75	15	30
Pineapple	50	80	10	20
Papaya	50	70	10	20
Lanzon	60	75	10	30
Rimas	60	75	10	25
Santol	65	80	15	20
Serali	60	80	15	30
Pumelo	60	70	10	20

[1] For other kinds of fruits, use the syrup concentration, time of exhaust and processing required by those which are the same or similar in texture and other characteristics to the fruits to be canned.

[2] One degree Brix equals one per cent sugar

TABLE 6.—*Time table for canning some vegetables* [a]

Name of vegetable	Concentration of brine	Exhausting for No. 2 cans		Processing	
		Temperature	Minutes	Temperature	Minutes
	Degrees salometer [1]	°C		°F	
Paayap or sitao	10°	80	15	240	35
Cabbage	10°	80	10	240	35
Bamboo shoots	10°	90	10	240	40
Mongo sprouts	10°	80	10	240	30
String beans	10°	80	15	240	40
Tomatoes	Solid pack [2]	70	10	212	30

[a] These results will be a good basis for canning other kinds of vegetables.

[1] Degrees salometer divided by four (4) gives per cent salt.

[2] Whole tomatoes.

TABLE 7.—*Relation between steam pressure of cookers in pounds per square inch and temperature in degrees Fahrenheit and centigrade.* [1]

Steam pressure pounds per square inch	Temperature in degrees	
	Fahrenheit	Centigrade
0	212	100
1	215	102
2	218	103
3	221	105
4	224	107
5	227	108
6	230	110
7	232	111
8	234	112
9	237	114
10	239	115
11	241	116
12	243	117
13	245	118
14	247	119
15	249	121

[1] Degrees Fahrenheit $= \frac{9C}{5} + 32$ where C = degrees Centigrade

Degrees centigrade $= \frac{5(F-32)}{9}$ where F = degrees Fahrenheit

TABLE 8.—*Approximate cost and dealers in canning equipment and accessories*

Article	Dealer and address	Approximate cost
1. Can sealing machine	1. American Can Co., 230 Park Ave., New York City, U. S. A. 2. Burpee Can Sealer, Chicago, Illinois, U. S. A. 3. Montgomery Ward Co., Chicago, Illinois, U. S. A.	From ₱18 to ₱100.
2. Can reforming machines	1. American Can Co., New York City	About ₱3,500.
3. Cookers	1. Denver Pressure Cooker Co., Denver, Colorado, U. S. A.	From ₱70 up.
4. Cookers and other canning equipment and accessories	2. Food Machinery Corporation, 70 Pine Street, San Francisco, Cal., U. S. A.	
5. Syrup and brine hydrometers	1. Botica Boie, Escolta, Manila 2. Botica de Santa Cruz, Plaza de Goiti, Manila.	From ₱2.50 up each.
6. Sanitary cans	1. American Can Company, 230 Park Ave., New York City. 2. Philippine Packing Corporation 3. Philippine Manufacturing Co., Manila, P. I.	*Collapsed cans* [1] No. 1—₱28.80 per M. No. 2—₱29.98 per M. No. 2½—₱50.42 per M. No. 10—₱120.66 per M. *Ready made plain cans* No. 1—₱44.20 per M. No. 2—₱53.60 per M. No. 2½—₱62.68 per M. No. 10—₱143.00 per M.

[1] These are U. S. A. prices. Local manufacturers charge a little higher M=one thousand

CHART 1.—*Fruiting seasons of Philippine fruits*

● Seasons of the year when the production is heaviest
≡ Fruiting seasons

Name of fruit	Months in year											
	January	February	March	April	May	June	July	August	September	October	November	December
ATES. *Annona squamosa* L.					≡	●	●	●	≡			
ATEMOYA. *Annona* sp.				≡	●	●	≡					
ANONAS. *Annona reticulata* L.		≡	≡	●	●	≡						
AVOCADO. *Persea americana* Mil.	≡				≡	≡	●	●	●	≡		≡
BANANA. *Musa paradisiaca* L.	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
BREADFRUIT. *Artocarpus communis* For.	≡			≡	●	●	●	≡			≡	≡
BERBA. *Rheedia edulis* P. & T.										≡	≡	≡
BALIMBING. *Averrhoa carambola* L.			≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
BAUNO. *Mangifera caesia* J.						≡	≡	≡	≡	≡		
BULALA. *Nephelium mutabili* Bl.				≡	≡	≡						
CAIMITO. *Chrysophyllum cainito* L.	≡	≡	●	●	≡							≡
CALAMANSI. *Citrus mitis* Bo.		≡	≡	≡	≡	≡	≡	≡	●	●	≡	
CAMANCHILE. *Pithecolobium dulce* Bth.			≡	●	≡							
CAMIAS. *Averrhoa bilimbi* L.	≡	≡	≡	≡	≡	≡	≡	≡			≡	≡
CHICO. *Achras zapota* L.	≡	≡	●	●	≡	≡	≡	≡	≡	≡	≡	≡
COCONUT. *Cocos nucifera* L.	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
CASOY. *Anacardium occidental* L.			≡	≡	≡	≡						
CHICO-MAMEY. *Calocarpum sapota* Pre.			≡	≡	≡			≡	≡	≡		
CONDOL. *Benincasa hispida* Cgn.	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
CATMON. *Dillenia philippinensis* Rfe.					≡	≡	≡	≡	≡	≡	≡	
CABUYAO. *Citrus hystrix* D. C.						≡	≡	≡	≡	≡	≡	≡
CAMANSI. *Artocarpus communis* For.				≡	≡	≡	≡					

CHART 1.—*Fruiting seasons of Philippine fruits*—Continued

● Seasons of the year when the production is heaviest

≡ Fruiting seasons

Name of fruit	Months in year											
	January	February	March	April	May	June	July	August	September	October	November	December
DUHAT. *Eugenia cumini* Dru.			≡	●	●	≡						
DURIAN. *Durio zibeth hinus* L.							≡	≡	●	●	≡	≡
GUAVA. *Psidium guajava* L.				≡	≡	●	●	●	≡	≡		
GOMIHAN. *Artocarpus elastica* Rwt.	≡		≡	≡	≡	≡	≡	≡				
GRAPEFRUIT. *Citrus maxima* M.	≡	≡	≡				≡	≡	≡	●	●	●
GALO. *Anacolasa luzoniensis* M.					≡	≡	≡					
GRAPES. *Vitis vinifera* L.	≡	≡	≡						≡	≡	≡	≡
GUANABANO. *Annona muricata* L.				≡	●	●	≡	≡	≡			
HEVI. *Spondias cytherea* Son.						≡	●	●	≡	≡	≡	≡
HUANI. *Mangifera odorata* Grif.				≡	≡	●	●	≡				
JACKFRUIT. *Artocarpus integra* M.	≡	≡	≡	≡	●	●	≡	≡				
KAYAM. *Inocarpus edulis* For.								≡	≡	≡	≡	
KETEMBILLA. *Dovyalis hebecarpa* Warb.										≡	≡	≡
LANZON. *Lansium domesticum* J.		≡	≡				≡	≡	●	●		
LEMASA. *Artocarpus champedom* Spr.			≡	≡	≡	≡	≡	≡	≡	≡	≡	
LEMON. *Citrus limonia* Osb.	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
LIME. *Citrus aurantifolia* Swg.	≡			≡	≡	≡	≡	≡	●	●	≡	≡
LIPOTE. *Eugenia curranii* C. B. R.				≡	●	●	≡	≡				
LITCHI. *Litchi chinensis* Son.						≡	≡	≡				
MABOLO. *Diospyrus discolor* Ww.				≡	≡	≡	≡	≡	●	●	≡	
MACOPA. *Eugeni javanica* L.			≡		≡	●	●	≡	≡			
MANDARIN. *Citrus nobilis* Lo.	●	≡								≡	≡	●
MANGO. *Mangifera indica* L.				≡	●	●	●	≡				
MANGOSTEEN. *Gacinia mangostana* L.	≡				≡	●	●	≡			≡	●
MARANG. *Artocarpus adoratissima* Bo.						≡	●	●	●	≡	≡	≡
MELON. *Cucumis melo* L.	≡	≡	●	●	●	≡						
MUSKMELON. *Cucumis melo* L.	≡	≡	●	●	≡							
ORANGE. *Citrus sinensis* Osb.	●	≡	≡						≡	≡	●	●
PAPAYA. *Carica papaya* L.	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
PILI. *Canarium ovatum* Eng.			≡	≡	≡	≡	≡					
PINEAPPLE. *Ananas comosus* M.				≡	●	●	≡					
PUMMELO. *Citrus maxima* M.	●	≡								≡	●	●
PAJO. *Mangifera altissima* Bo.				≡	≡							
POMEGRANATE. *Purica granatum* L.				≡	≡				≡	≡	≡	
PERUNKILA. *Carissa carandas* L.					≡	≡	≡					
ROSELLE. *Hibiscus sabdariffa* L.	≡	≡								≡	≡	≡
RAMBUTAN. *Nephelium lappaccum* L.						≡	≡	≡	≡	≡		
SINIGUELAS. *Spondias purpurea* L.				≡	●	≡	≡					
SANTOL. *Sandoricum koetjape* M.				≡	●	●	≡	≡	≡			
SERALI. *Flacourtia ramontchi* l'Iter.		≡	≡	●	●	≡	≡	≡	●	≡		
STRAWBERRY. *Fragraria chiloensis* Deh.	≡	≡	≡	●	●							
TAMARIND. *Tamarindus indica* L.	≡	≡	●	●	≡	≡	≡		≡	≡	≡	≡
TAMPOY. *Eugenia calubcob* C. B. R.			≡	≡	≡	≡						
TERSANA. *Eugenia malaccensis* L.							≡	≡	≡	≡		
TIESSA. *Lucuma nervosa* A. D. C.	≡					≡	●	●	≡	≡	≡	≡
WATERMELON. *Citrullus vulgaris* Schr.	≡	≡	●	●	≡	≡	≡					
ZAPOTE. *Diospyros obenaster* Retz.	≡	≡	≡	≡				≡	≡	●	●	≡

CHART 2.—*Harvesting seasons of Philippine vegetables*

● Seasons of the year when the production is heaviest
≡ Seasons for vegetables

Name of vegetable	Months in year											
	January	February	March	April	May	June	July	August	September	October	November	December
AMPALAYA. *Momordica charantia* L.	≡	≡	≡	≡				≡	●	≡	≡	≡
ARROWROOT. *Maranta arundinacea* L.	≡	≡	≡	≡	≡							≡
BEET. *Beta vulgaris* Mog.	≡	≡	●	●	≡	≡				≡	≡	≡
BEANS. *Phaseolus vulgaris* D. C.	≡	●	●	●	≡	≡			●	≡	≡	≡
BATAO. *Dolichos lablab* L.	≡	≡	≡	≡	≡					≡	≡	≡
CATURAY. *Sesbania grandiflora* Pers.	≡	≡	●	≡	≡							≡
CABBAGE. *Brassica oleracea var. capitata* Hort.	≡	●	●	●	≡	≡			●	≡	≡	≡
CHAYOTE. *Sechium edule* Sw				●	●	●	●	≡	≡	≡	≡	≡
CELERY. *Apium graveolens* L.		≡	≡	≡	≡							
CAULIFLOWER. *Brassica oleracea var. botrytis* D. C.		≡	≡	≡	≡							
CUCUMBER. *Cucumis sativus* L.	≡	≡	≡					≡	●	≡	≡	≡
CAMOTE. *Ipomea batatas* L.	≡	≡	≡	≡				≡	≡	≡	≡	≡
CASSAVA. *Manihot utilissima* Pohl.	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
EGGPLANT. *Solanum melongena* L.	≡	≡	≡	●				●	●	≡	≡	≡
ENDIVE. *Chihorium endivia* L.	≡	≡	≡	≡								≡
GABI. *Colocasia esculenta* Sct.	≡	≡	≡	≡								≡
GARLIC. *Allium sativum* L.		≡	≡	≡	≡							≡
GINGER. *Zingiber officinale* Rosc.	≡	≡	≡	≡	≡							
KOHLRABI. *Brassica oleracea var. caulorapa* Hort.	≡	≡	≡									≡
KIBAL. *Vigna sinensis* Savi.			≡	≡	≡				≡	●	≡	
LETTUCE. *Lactuca sativa* L.	≡	≡	≡	≡	≡	≡	≡	≡	●	≡	≡	≡
LABONG. *Bambusa spinosa* Rxb.					≡	≡	≡	≡	●			
MUSHROOM. *Agaricinae*						≡	●	≡				
MUSTARD. *Brassica integrifolia* O. E. S.	≡	≡	≡	≡				●	≡	≡	≡	≡
MONGO. *Phaseolus aureus* Rxb.	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
ONION. *Allium cepa* L.	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
PATANI. *Phaseolus lunatus* L.	≡	●	●	≡						≡	≡	≡
PATOLA. *Luffa cylindrica* Roem.	≡	≡	≡	≡					●	≡	≡	≡
PECHAY. *Brassica cernua* F. & H.	≡	≡	≡				≡	≡	●	≡	≡	≡
PEAS. *Pisum sativum* L.	≡	≡	≡					≡	≡	≡	≡	≡
PEANUTS. *Arachis hypogaea* L.	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡
PEPPER. *Piper nigrum* L.	≡	≡	≡	≡			≡	≡	●	≡	≡	≡
POTATO. *Solanum tuberosum* L.		≡	≡	≡	≡							
RADISH. *Paphanus sativus* L.	≡	≡	≡				●	●	≡	≡	≡	≡
SEGUIDILLAS. *Psophocarpus tetragonolobus* D. C.	≡	≡	≡	≡						≡	≡	≡
SITAO. *Vigna sinensis var. sesquipedalis* Fruw.	≡	≡	≡					≡	●	≡	≡	≡
SPINACH. *Spinacia oleracca. L.*			≡	≡	≡	≡	≡	≡	●	≡		
SQUASH. *Cucurbita maxima* Dch.	≡	≡	≡	≡	≡					≡	≡	≡
SINCAMAS. *Pachyrrhizus erosus* Urb.	≡	≡	≡	≡	≡							
TOMATO. *Lycopersicum esculemtum* Mil.	≡	≡	≡	●	●	≡		≡	≡			≡
WATERMELON. *Citrullus vulgaris* Schr.	≡	≡	≡	≡	≡							

ILLUSTRATIONS

PLATE I. A corner in the Agricultural Chemistry Booth, Bureau of Plant Industry Exhibition held at Singalong, Manila, September 5–18, 1932, showing the equipment for one cooperative canning unit for farmers' wives.

II. (*a*) Vertical types of pressure cookers used in sterilizing vegetables.

(*b*) Open and steam cookers for sterilization of fruits and other food products.

III. (*a*) Samples of tin cans and Nestrite cups or cartons used in packing food products.

(*b*) A simple hand-sealing or can-closing machine, empty cans, and canned food products. Agricultural Chemistry Laboratory, Bureau of Plant Industry, Manila.

IV. (*a*) A case showing packing of "collapsed" or "knocked out" tin cans. The expense of transporting collapsed cans is very small compared with that for ready-made tins. When large quantities of tin cans are to be used, collapsed cans are preferable. (American Can Co.)

(*b*) Brix salometer and Baumé hydrometers that are used in determining syrup and brine concentrations.

V. A corner in the Agricultural Chemistry Booth, Bureau of Plant Industry Exhibition held at Singalong, Manila, September 5 to 18, 1932, showing canned and other finished products produced in the plant utilization laboratory of the Bureau of Plant Industry.

VI. Canned Philippine fruits, vegetables and other food products prepared in the Agricultural Chemistry Laboratory of the Bureau of Plant Industry.

VII. (*a*) A Canco horn press with flanging die (Flanging Machine, a part of the can-reforming outfit). (American Can Co.)

(*b*) A semi-automatic machine with end feed, part of can-reforming unit. (American Can Co.)

VIII. (*a*) A sketch of the different working parts of a can reforming machine. (American Can Co.)

(*b*) A semi-automatic can body reforming machine. (American Can Co., New York.)

IX. Different types of hand and power driven can closing machines, (Food Machinery Corporation, San Francisco, California.)

(*a*) Double seamer and closing machine.

(*b*) Closing machine for round cans and metal containers.

(*c*) Hand power double seamer closing machine.

(*d*) Simplex vacuum can sealing machine.

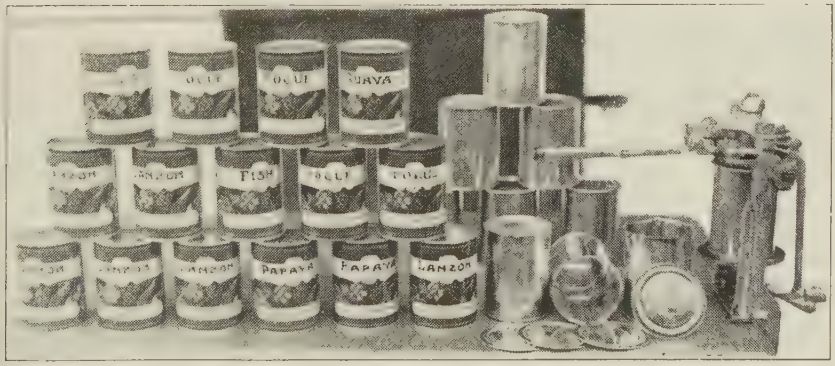
PLATE I. A corner in the Agricultural Chemistry Booth, Bureau of Plant [illegible] held at Singalong, Manila, September 5 to 18, 1932, showing the equipment for one coöperative canning unit for farmers' wives.

(*a*) Vertical types of pressure cookers used in sterilizing vegetables

(*b*) Open and steam cookers for sterilization of fruits and other food products

PLATE II

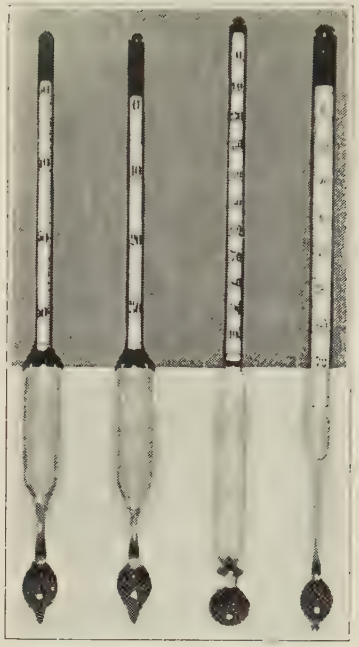
(*a*) Samples of tin cans and Nestrite cups or cartons used in packing food products



(*b*) A simple hand-sealing or can-closing machine, empty cans, and canned food products. Agricultural Chemistry Laboratory, Bureau of Plant Industry, Manila

PLATE III

(*a*) A case showing packing of "collapsed" or "knock out" tin cans. The expense of transporting collapsed cans is very small compared with that for ready-made tins. When large quantities of tin cans are to be used, collapsed cans are preferable. (American Can Co.)



(*b*) Brix salometer, and Baumé hydrometers that are used in determing syrup and brine concentrations.

PLATE IV

PLATE V. A corner in the Agricultural Chemistry Booth, Bureau of Plant Industry Exhibition held at Singalong, Manila, September 8 to 18, 1932 showing canned and other fish and products produced in the plant utilization laboratory of the Bureau of Plant Industry.

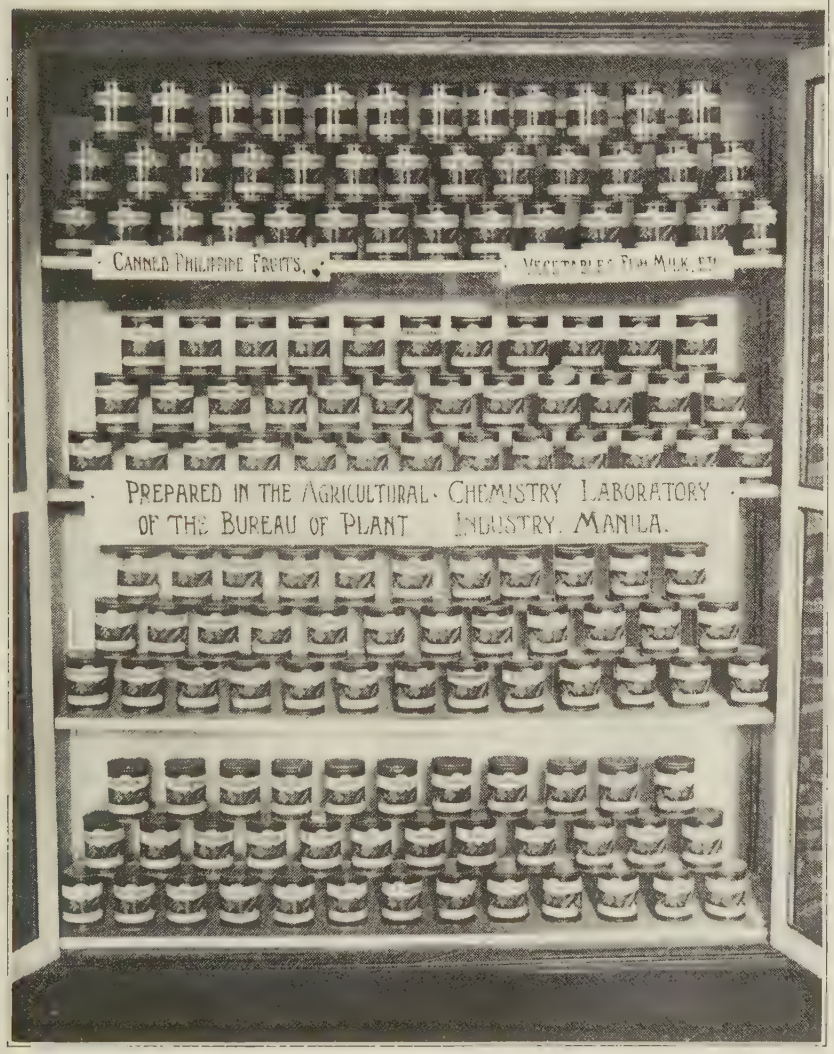
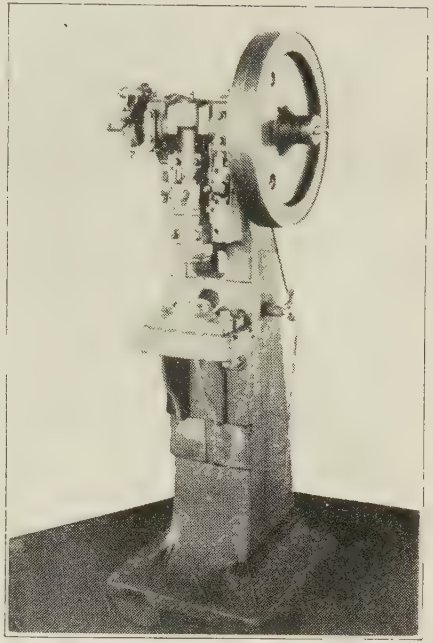
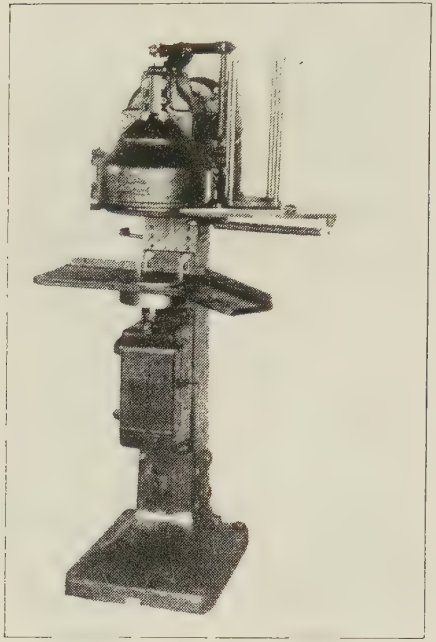


PLATE VI. Canned Philippine fruits, vegetables and other food products prepared in the Agricultural Chemistry Laboratory of the Bureau of Plant Industry

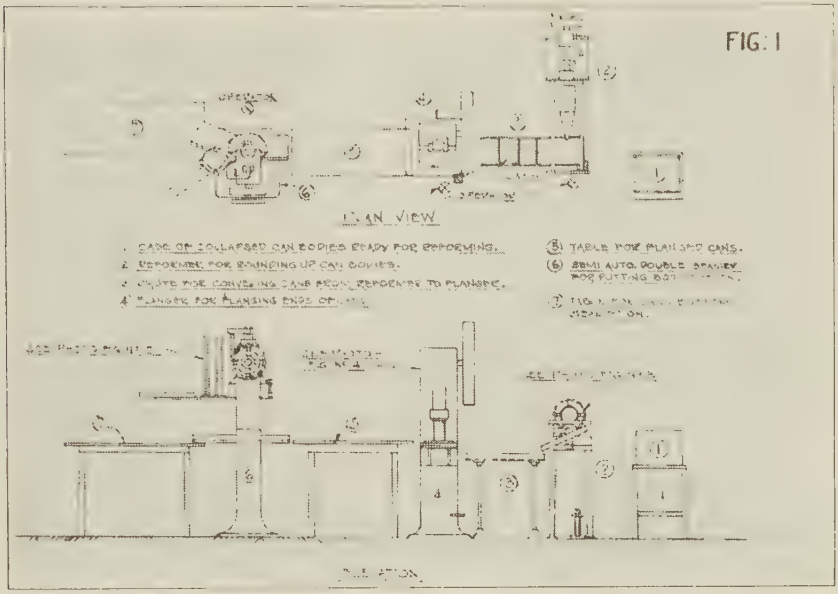


(*a*) A Canco horn press with flanging die (Flanging Machine, a part of the can-reforming outfit). (American Can Co.)

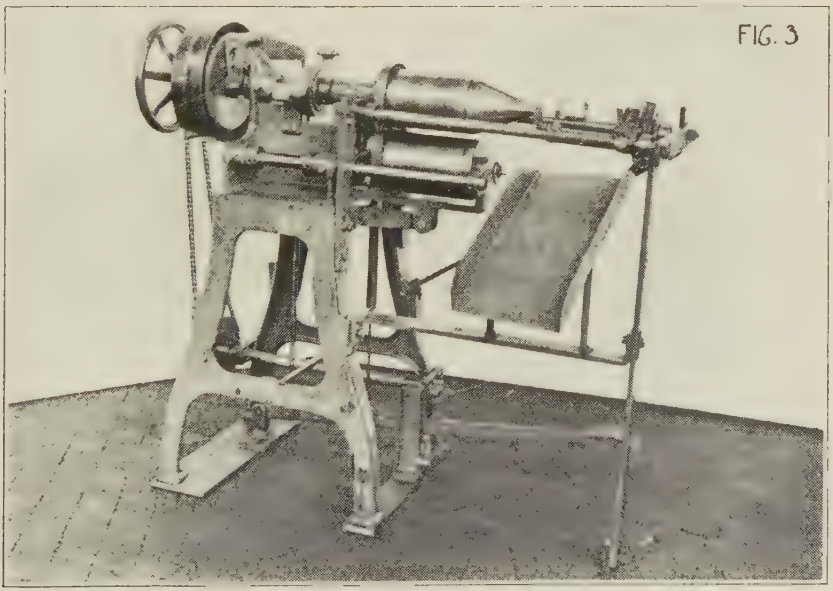


(*b*) A semi-automatic machine with end feed, part of can-reforming unit. (American Can Co.)

PLATE VII

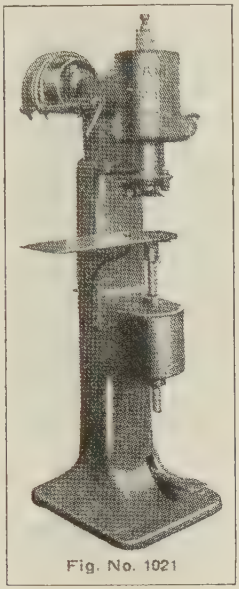


(*a*) A sketch of the different working parts of a can reforming machine. (American Can Co.)

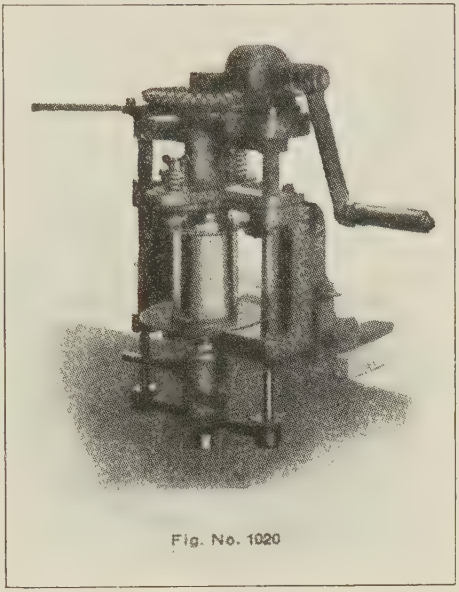


(*b*) A semi-automatic can body reforming machine. (American Can Co., New York)

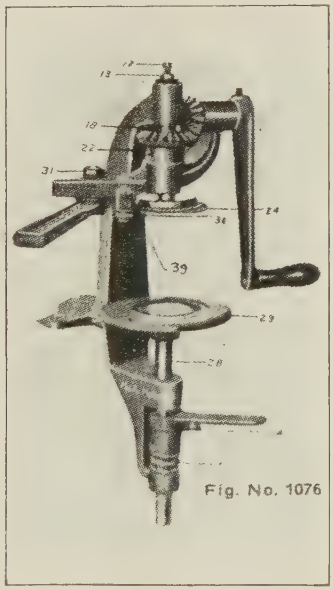
PLATE VIII



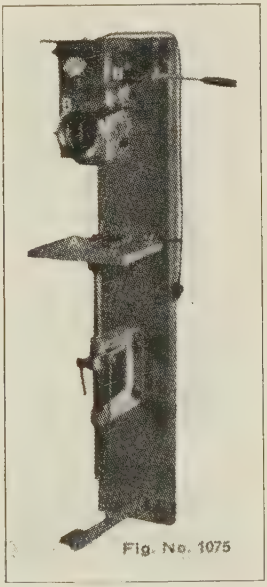
(*a*) Double seamer and closing machine



(*b*) Closing machine for round cans and metal containers



(*c*) Hand power double seamer closing machine



(*d*) Simplex vacuum can sealing machine

PLATE IX. Different types of hand and power driven can closing machines. (Food Machinery Corporation, San Francisco, California)

A PROPHYLACTIC VACCINE AGAINST HEMORRHAGIC SEPTICEMIA (BARBONE)

By Teodulo Topacio, B.Sc., D.V.M., M.Sc., D.Sc.
Veterinarian, Bureau of Animal Industry

TWO PLATES

HISTORICAL

Hemorrhagic septicemia (barbone) of cattle and carabaos has been in the Philippines from time immemorial. During the past thirty years the disease was no doubt confused with rinderpest and anthrax, which often appeared simultaneously in one locality. In the usual form, it occurs in sporadic or enzoötic outbreaks and is widespread in several countries of the world. The flares are most frequent during a hot summer followed by heavy rains. The sporadic nature of the ailment has not engaged the attention it deserves except when it assumed an epizoötic form, when sanitarians were then forced to take preventive measures. This attitude, while the same all over the world, is not warranted. A search for a more effective prophylaxis should be carried on.

Following the isolation of the septicemia germ (*Bacillus bovisepticus,* Kitt; *Pasteurella boviseptica,* Trevisan) by Kitt,(1) much work on the preparation of prophylactic vaccines and sera against this disease has been done in various countries of the world. Pasteur's (1879) accidental discovery of his fowl cholera vaccine—cultures of *Pasteurella avicida* attenuated by keeping them at room temperature and exposing to free oxygen for weeks and months—led many workers to apply this method to other septicemia organisms, with varying results. Some investigators attempted attenuation by heat, while others employed various chemical antiseptics; notably phenol, cresol, formalin, etc., but so far, the resulting vaccines have varied so greatly in their protective quality as to be of little value for general use in control work. In the United States, Mohler and Eichhorn (1912) apparently succeeded in immunizing buffaloes at Yellowstone Park with living cultures of septicemia organisms attenuated at 42.5°C. Two vaccines were prepared. Vaccine No. 1 consisted of cultures grown at 42.5°C. for five days and vac-

cine No. 2, cultures 48 hours old. Hardenbergh and Boerner(2) using a similar technique, prepared a vaccine which they used in Pennsylvania with a mortality of but 1.8 per cent. R. P. Jones(3), veterinary adviser to the Ministry of Commerce and Communications of Siam, reports that for two years the Government of Siam has employed, with excellent results in the control of seasonal enzoötic outbreaks among buffaloes, a single-injection vaccine prepared after the method of Holmes. De Vine(4) of New York reports the successful use of his bacterin both as a prophylactic and as a curative measure. Balozet(5) uses a killed 48-hour culture of several strains of *Pasteurella boviseptica* followed by a 24-hour culture of the fowl cholera organism.

Without going into a discussion of the comparative efficacy of the various vaccine preparations, this paper describes a prophylactic vaccine that is giving very satisfactory results in the prevention of septicemia of carabaos and cattle in the Philippines. To the best of the writer's knowledge, there has been no previous work dealing with this subject in local literature.

NOMENCLATURE

Pasteur was the first to apply the word "vaccine" to an emulsion of dead or attenuated bacteria. Edward Jenner employed the word "vaccination" for inoculation with the cowpox virus. Since then, there has been an arbitrary application of this term in literature. S. Solis Cohen(6) introduced the term "bacterin" to designate a suspension of dead bacteria in contradistinction to the word "vaccine," which is a suspension of living organisms. While the term "vaccine" is rather unqualified, nevertheless it better expresses the real biological nature of the product than does Cohen's descriptive term. The ending "*in*" in "bacterin" implies an extract of bacteria such as "tuberculin," "leprolin," "Johnin," "mallein," etc. and is therefore misleading. Present workers, therefore, prefer the term "vaccine" to embrace suspensions of dead or attenuated organisms. "Bacterin" is fast becoming an obsolete term in human practice. In this paper the word "vaccine" has been used exclusively.

MATERIALS

Experimental animals.—In carrying out the preparation of this vaccine, white rabbits raised in our own laboratory were employed as test animals. Adults weighing approximately 1½ to 2 kilograms were selected in order to maintain a standard

of age, size, and weight. Our records show that there has been no outbreak of any bacterial infection among these animals during the past five years. Likewise, the carabaos and cattle utilized in parallel tests were procured from Dalupiri Islands and other localities known to be free from hemorrhagic septicemia infection. It is a recognized fact that the standardization of experimental animals is an important requirement in the manufacture of any biological product.

Stock cultures.—The Buencamino Laboratories, Inc., Manila, P. I., kindly supplied me a strain of buffalo septicemia organisms. This was the initial stock strain used in this work. During a recent outbreak of septicemia in the island of Mindoro, a local strain was isolated from a carabao which died of the disease. Parallel tests of these two strains were made in order to determine their virulence and immunizing capacity and the results were carefully compared. Fortunately, when made into a vaccine, each strain conferred protection to the test animals. Both strains were uniformly fatal to rabbits in a dose of 0.0001 cc. to 0.001 cc. of a 24-hour broth culture, the animals dying within 24 to 48 hours after subcutaneous injection. Those who have had any experience with the septicemia organisms realize full well the difficulty of preserving their virulence on artificial media. To overcome this very important obstacle, it is my practice to make frequent passages of each strain through rabbits at determined intervals with the result that there has been no deterioration of virulence in any series.

Minimal lethal dose.—After repeated trials, it was found that ½ cc. of broth culture containing 12,500 to 15,000 bacteria invariably killed rabbits from 24 to 48 hours after subcutaneous injection. Twice these numbers killed rabbits promptly in 24 hours. Likewise, by injecting subcutaneously 6,000 to 7,000 organisms, death was often delayed to 7 days. Carabaos and cattle may not die when injected with 150 million organisms but 300 to 600 millions kill them regularly. It appears, therefore, that the minimal lethal dose in cattle and carabaos which kills in 48 hours is in the neighborhood of 20,000 to 50,000 times that of the rabbit.

Culture media.—In the preparation of culture media a great deal depends upon the quality of ingredients which enter into their composition. These must be of the best kind procurable, otherwise uniform results cannot be expected of them. In this work, emphasis was placed on adopting a uniform working system in such details as accurate measurement of each ingredient.

processing, adjustment of chemical reaction, tubing or bottling, sterilization and testing for sterility in the final state.

(*a*) *Base infusion.*—Fresh lean beef or carabao meat from recently slaughtered animals is freed of fats and fascia and passed through a meat grinder. To 1,000 grams of meat mash 2,000 cc. of distilled water is added. The mixture is allowed to infuse at 0°C. to 5°C. for 24 hours and strained through a double layer of cheesecloth. A simple broth is prepared in the usual method without titration.

(*b*) *Stock infusion broth.*—To every liter of base infusion 10 grams of Witte or Bacto peptone and 5 grams of NaCl (C.P.) are added. The mixture is boiled for a few minutes, filtered through filter paper and adjusted to pH 7.8, cooled to 60°C. and refiltered through filter paper while hot, then sterilized in the Arnold by the fractional method for three consecutive days. As a test for sterility, it is incubated at 37°C. for two or three days before use.

(*c*) *Infusion agar.*—A quadruple strength infusion broth is diluted to simple broth and 2 per cent agar is added. After filtration and while hot the agar solution is dispensed in quart square-faced gin bottles in 50 cc. amounts. The charged bottles are autoclaved for 30 minutes at 15 pounds pressure and placed on the table in a horizontal position until the agar has solidified. They are incubated two or three days before use.

METHODS

Seed broth.—This consists of a heart or beef infusion proteose broth. One agar slant culture of *Pasteurella boviseptica* recently isolated from a rabbit is washed and the entire washing inoculated into a 200 cc. broth culture. This is incubated for 24 hours at 37° C. and after testing for purity is distributed in 2 cc. to 4 cc. amounts to each agar slant in the large square bottles previously described.

Agar bottle cultures.—The square bottle agar slopes thus inoculated are incubated at 37° C. for 3 or 4 days. These, in turn, are washed with about 10 cc. of broth or saline per bottle. The washing from each bottle is tested for purity by microscopic examination of stained smears and those having contamination are described.

Final infusion broth culture.—Bottles containing 4.5 liters of broths are inoculated with the washings of 3 or more agar slopes to the liter of broth depending upon the thickness of growth. The washings are poured into the broth bottles through a sterile glass funnel under aseptic conditions. The broth bottles are plugged and then incubated for 24 to 48 hours at 37° C. Chemically pure phenol is added to each bottle of broth culture to a concentration of 0.5 per cent. The gauze pluge is replaced by a special puncturable rubber cap stopper and each bottle thus treated is shaken vigorously and again incubated at 37° C. for 24 to 48 hours. At the end of this period the phenolized culture is ready for purity and potency tests. This is the technique used in preparing the vaccine employed in these experiments.

Standardization.—Just before the addition of phenol for the second incubation, samples of an equal quantity are taken from each vaccine bottle and pooled in one container for bacterial count. The results of a number of trials of such mixtures by direct counts with Wright's or he-

mocytometer methods, have been compared with the McFarland nephelometer standards until a close agreement was reached. It was determined that in general, the nephelometer readings were sufficiently accurate for ordinary routine. Average readings of vaccines prepared by this method varied from 250 million to 600 million bacteria per cubic centimeter.

Sterility test.—To 100 cc. of hormone sterility broth 10 cc. of sample vaccine is added. Agar slants are also inoculated at the same time. The inoculated media are incubated at 37° C. for 48 hours or more before examination. When two strains of organism are to be used, the vaccine prepared from each is standardized and tested separately. If the vaccine or vaccines prove sterile then the contents of the different bottles are pooled by a half and half ratio into larger sterile bottles or demijohns before final bottling and dispensing. A final purity test is run at random on a number of bottles of the finished product. The finished vaccine is dispensed in 100 cc. bottles.

Potency test.—One to two rabbits are injected subcutaneously with 5 cc. of the vaccine to be tested. Ten days later, the vaccinated animals with one control are injected with ½ cc. of a 24-hour virulent broth culture containing 12,500 to 15,000 organisms. If the vaccine is potent the inoculated rabbits survive while the control dies in 24 to 48 hours. Besides the test on rabbits, each vaccine is also tested on one carabao and one vaca as an additional safeguard. Each receives 1 to 2 cc. of a 24-hour broth culture 10 days after vaccination. The vaccine is ready for use when the rabbits and large animals pass the inoculation test.

EXPERIMENTAL

When Doctor Tuft(7) published his report on the successful intradermal vaccination against typhoid, the writer had it in mind to ascertain if this method could be applied to hemorrhagic septicemia as well. In the following experiments, the work was further extended to different routes of vaccination.

Experiment 1.—Rabbits R–1 and R–2 received a vaccine containing 250 million bacteria per cubic centimeter attenuated in the water bath for one-half hour at 58°C. This method of preparing the vaccine is along the same technique used in preparing typhoid vaccine. Four ascending doses were given intradermally at intervals of one week. A week after the first intradermal injections of rabbit R–1 and R–2 the idea was also conceived to inoculate two other rabbits, R–3 and R–4, subcutaneously with increasing doses of phenolized vaccine containing 250 million bacteria per cubic centimeter. Ten days after the last intradermal and subcutaneous injections, each rabbit in both tests received subcutaneously ½ cc. of virulent broth culture containing 12,500 bacteria. Two control rabbits were inoculated with virulent culture alone, one receiving 12,500 and the other 6,000 organisms respectively. The four vaccinated rabbits re-

sisted the test inoculation while the controls died, the first in 48 hours and the second in 7 days. Details of the experiment are summarized in Table 1.

TABLE 1.—*Weekly intradermal vaccination with the Mindoro strain attenuated at 58° C. for thirty minutes in water bath*

Rabbit number	First dose	Second dose	Third dose	Fourth dose	Virulent 24-hour broth culture	Result
	cc.	*cc.*	*cc.*	*cc.*		
R-1	0.1	0.2	0.3	0.5	½ cc. containing 12,500 bacteria.	Lived.
R-2	0.1	0.2	0.3	0.5	.....do.....	Do.

Weekly subcutaneous vaccination with the Mindoro strain attenuated with 0.5 per cent phenol for 24 hours at 37° C.

	cc.	*cc.*	*cc.*	*cc.*		
R-3	1.0	1.5	2.0	.....	½ cc. containing 12,500 bacteria.	Lived.
R-4	1.0	1.5	2.0	.....	.....do.....	Do.
R (1)	[a]	[a]	[a]	.....	.....do.....	Died in 48 hours.
R (2)	[a]	[a]	[a]	.....	.....do.....	Died in 7 days.

[a] Control

Experiment 2.—Having succeeded in protecting rabbits by the intradermal and subcutaneous routes, it was decided to test this phenolized vaccine on large animals using a concentration of about 300 million per cubic centimeter at a dose of 10 cc. per animal, given subcutaneously. Accordingly, cattle Nos. 1831, 1863, 1868, 1872, 1898 and carabaos 1151 and 1167 were vaccinated with the stated dose. Ten days after the injection, 2 cc. of a 24-hour virulent culture containing 600 million bacteria were given to every animal including control carabao No. 1152. This test dose is about 50,000 times the lethal dose in rabbits which are killed in 48 hours. All vaccinated cattle and carabaos survived while the control died after 48 hours. A rise of temperature was observed in some animals. Table 2 is a summary of this experiment.

TABLE 2.—*Immunization of cattle and carabaos with phenolized vaccine*

Animal number	Vaccine strain	Dose	Dose of virulent broth culture	Result
		cc.		
Cattle 1831.....	Bufalo.....	10	2 cc. containing 600 million bacteria.	Lived.
Cattle 1863.....	.....do.....	10	.....do.....	Do.
Cattle 1868.....	.....do.....	10	.....do.....	Do.
Cattle 1872.....	.....do.....	10	.....do.....	Do.
Cattle 1898.....	.....do.....	10	.....do.....	Do.
Carabao 1151.....	.....do.....	10	.....do.....	Do.
Carabao 1167.....	.....do.....	10	.....do.....	Do.
Carabao 1152.....	[a]	[a]	.....do.....	Died in 48 hours.

[a] Control

The result of the above experiment is decisive and leaves no room for doubt as to the protective quality of the vaccine. Successful resistance of the vaccinated animals against a test dose of virulent culture 50,000 times the lethal dose in rabbits could imply nothing less than a high degree of protection, particularly when one considers the extreme virulence of the test strain. As stated elsewhere, the test cultures are constantly maintained in rabbits to insure uniform pathogenicity.

Experiment 3.—For the purpose of testing the value of vaccines prepared with local strains, it was decided to immunize rabbits with the separate vaccines. Eight animals were injected subcutaneously in doses of 4 to 5 cc. of each type of vaccine with a concentration of 300 million per cubic centimeter employing a similar technique of preparation and inoculation for each vaccine. The buffalo, Mindoro and Batangas strains, were tested separately. Details of the comparative result are summarized in Table 3.

TABLE 3.—*Immunization of rabbits with vaccines prepared with the buffalo, Mindoro and Batangas strains*

Rabbit number	Vaccine strain	Dose	Virulent 24-hour broth culture	Result
		cc.		
R–5	Buffalo	4	½ cc. containing 12,500 bacteria.	Lived.
R–6	do	4	do	Do.
R–7	do	4	do	Do.
R–8	do	4	do	Died.
R–9	do	5	do	Lived.
R–10	do	5	do	Do.
R–11	do	5	do	Do.
R–12	do	5	do	Died.[1]
R–13	Mindoro	4	do	Do.
R–14	do	4	do	Lived.
R–15	do	4	do	Do.
R–16	do	4	do	Do.
R–17	do	5	do	Do.
R–18	do	5	do	Died.
R–19	do	5	do	Lived.
R–20	do	5	do	Do.
R–21	Batangas	4	do	Died.
R–22	do	4	do	Do.
R–23	do	4	do	Do.
R–24	do	4	do	Do.
R–25	do	5	do	Lived.
R–26	do	5	do	Died.
R–27	do	5	do	Do.
R–28	do	5	do	Lived.
R (3)	(2)	(2)	do	Died in 24 hours.

[1] Complications [2] Control

The seeming discrepancy in the results observed in this experiment in rabbits indicates clearly that the Batangas strain is not antigenic even though it has been passed through rabbits. Likewise, the sugar reaction of this strain did not conform with that of the typical antigenic strains. According to this ob-

servation, it appears that the antigenic index of a given strain may be judged before hand by its sugar reaction. That is to say, an unknown strain giving a typical sugar reaction might be anticipated to yield an antigenic vaccine. Several local strains isolated from field sources have been discarded on this ground, because when tested on rabbits they were found to be feebly or not at all antigenic.

Experiment 4.—This experiment is designated to determine in a preliminary way the degree of protection conferred by vaccines of disimilar strains, the buffalo and Mindoro strains being selected. In rabbits the buffalo strain failed in one instance out of four, while the Mindoro strain failed twice. On the other hand both strains protected every carabao injected. All the controls died after 48 hours. It is quite obvious that in carabaos the result was perfect, while in rabbits both vaccines showed a slight defficiency. Table 4 is a summary of methods and results.

TABLE 4.—*Immunity tests on rabbits four weeks after a single subcutaneous injection*

Rabbit number	Vaccine strain	Dose	Virulent 24-hour broth culture	Result
		cc.		
R–29	Buffalo	5	½ cc. containing 12,500 bacteria	Lived.
R–30	do	5	do	Do.
R–31	do	5	do	Died.
R–32	do	5	do	Lived.
R–33	Mindoro	5	do	Do.
R–34	do	5	do	Died.
R–35	do	5	do	Do.
R–36	do	5	do	Lived.
R (4)	(a)	(a)	do	Died in 48 hours.

Immunity tests on carabaos thirty-six days after a single subcutaneous injection

Carabao number	Vaccine strain	Dose	Virulent 24-hour broth culture	Result
		cc.		
829	Buffalo	10	2 cc. containing 600 million bacteria	Lived.
831	do	10	do	Do.
993	do	10	do	Do.
1880	do	10	do	Do.
563	Mindoro	10	do	Do.
693	do	10	do	Do.
821	do	10	do	Do.
830	do	10	do	Do.
880	(a)	(a)	do	Died in 48 hours.

[a] Control

Further tests with vaccines of these two strains have demonstrated that they were, generally speaking, practically of the same potency. Moreover, when both strains were combined into

a vaccine, the product was invariably efficient both in rabbits and large animals. This double strain vaccine has been employed exclusively in the succeeding experiments.

The outstanding result of this experiment is the fact that immunity in vaccinated animals under laboratory conditions obviously lasts 36 days after vaccination. This period of protection against a severe test dose is a clear evidence of potency. The statement may be made that this immunity is sufficient to protect animals against ordinary field exposure since it is difficult for a natural infection to duplicate the severity of direct inoculation with virulent cultures.

Experiment 5.—In the foregoing tests it was observed that some rabbits did not resist the test dose of virulent culture, whereas the cattle and carabaos were regularly protected. Setting aside the factors of individual susceptibility on the one hand and virulence on the other, the question of ascertaining the immunizing value of the component fractions of the vaccine suggested itself in order to clarify this apparent discrepancy. Accordingly, vaccine serials 6 and 7 were tested. Each vaccine was centrifuged and the supernatant fluid was separated from the sediment. A sufficient amount of supernatant fluid was filtered through a Berkefeld candle. The filtrate, supernatant fluid and the whole vaccine were then injected into rabbits separately in the following proportions: whole vaccine, 5 cc.; supernatant fluid, 10 cc.; and filtrate, 10 cc. When given the test dose of virulent culture, only the animals receiving whole vaccine resisted while those injected with the other fractions died. Although the vaccines were more concentrated, the filtrate and the supernatant fluid given in twice the dose of whole vaccine completely failed to protect. It would appear that the immunizing factor resides in the whole vaccine and not in the supernatant fluid nor in the filtrate.

TABLE 5.—*Antigenic value of supernatant fluid and filtrate compared with whole vaccine injected subcutaneously*

Rabbit number	Vaccine serial	Dose	Virulent 24-hour broth culture	Result
R–37	6	5 cc. whole vaccine	½ cc. containing 12,500 bacteria.	Lived.
R–38	6	10 cc. supernatant fluid	do	Died.
R–39	6	10 cc. filtrate	do	Do.
R–40	7	5 cc. whole vaccine	do	Lived.
R–41	7	10 cc. supernatant fluid	do	Died.
R–42	7	10 cc. filtrate	do	Do.
R (5)	(a)	(a)	do	Died in 48 hours.

[a] Control

Experiment 6.—In the course of an ordinary natural infection there appears in the region of the neck of affected carabaos or cattle a subcutaneous edema extending from the throat sometimes along the entire length of the neck to the ventral surface of the abdomen. For the purpose of determining if this might be due to a separable toxin produced by the organisms, the supernatant fluid and the filtrate of a vaccine prepared by incubating broth culture for six days were injected intradermally into rabbits. Using a tuberculin syringe with a 25 gauge needle, the shaved skin was injected in three spots with 0.4 cc. of supernatant fluid. In another rabbit the filtrate was injected in like manner. In both cases an area of erythema without edema developed around the point of inoculation, the size varying from ½ to 2½ centimeters in diameter which became distinct in 48 hours. Within a week the areas cleared up leaving a superficial brownish necrosed epidermis which scaled off. A pale white hairless scar marked the point of inoculation. (Plate II, figs. 1 and 2.)

From this it would appear that there is a certain toxic substance in the filtrate and supernatant fluid in broth culture vaccines incubated for 6 days at 37° C. Judging from the frailness of these organisms which begin to disintegrate early in incubation, such toxin appears to be preëminently endobacterial in nature. Intravenous injection of each fraction failed to cause death in rabbits, but dopiness and pallor of the eye membranes were observed in the animals. In this connection, it is to be noted that the different fractions and even whole vaccine given intravenously in 5 cc. doses failed to protect rabbits against the test dose of virulent culture.

TABLE 6.—*Intravenous injection of whole vaccine supernatant fluid and filtrate*

Rabbit number	Vaccine serial	Dose	Virulent 24-hour broth culture	Result
R–43	6	5 cc. whole vaccine	½ cc. containing 12,500 bacteria.	Died in 48 hours.
R–44	6	do	do	Do.
R–45	6	5 cc. supernatant fluid	do	Do.
R–46	6	do	do	Do.
R–47	6	5 cc. filtrate	do	Do.
R–48	6	do	do	Do.
R (6)	(a)	(a)	do	Do.

[a] Control

Experiment 7.—Since there were certain skin reactions observed in rabbits injected intradermally, another toxicity test was performed on carabaos and cattle, but the different fractions were given subcutaneously. The fractions of serials 5, 6 and 7 were utilized for this purpose; thus, whole vaccine, supernantant fluid, filtrate and sediment each suspended in 25 cc. saline were administered. Each fraction was injected in 25 cc. dosage on the same day to 24 animals, thus allowing two animals for each fraction. Twenty-four hours after injection on one side of the animal, there was heat, sensitiveness and flat swellings of varying degree at the site of inoculation. The reaction was most marked on animals receiving the whole vaccine and supernatant fluids of serials 5 and 6, probably because these were incubated much longer (6 days) than serial 7 during preparation. Concentration and long incubation account for greater bacterial disintegration and consequent presence of a more concentrated endo-bacterial toxin (endotoxin). Furthermore, serial 7 was much less concentrated than the other two when originally prepared. The bulk of the 25 cc. dose may have partly induced additional mechanical irritation.

The swellings on all animals injected with serials 5 and 6 disappeared after four days, while in those given serial 7 the reaction was either negative or slight. No other visible signs of a toxic nature were seen immediately after injection or during the period of observation.

With respect to the supernatant fraction, on the whole the reactions in this experiment tallied with those observed in the rabbits in the preceding test, except in the case of the whole vaccine and the filtrate. It will be recalled that the supernatant fluid and the filtrate furnished greater signs of toxicity for the rabbit skin in contrast to the whole vaccine. In carabaos, however, the whole vaccine and supernatant fluid seem to have elicited more reactions (Table 7). On account of the difference in the routes of injection in the two species of animals, it is realized that the comparison is not absolute, but since in general the skin responses appeared to be quite alike, particularly

with regard to the supernatant fluid, one is led to consider such a comparison justified.

TABLE 7.—*Toxicity tests of the vaccine on cattle and carabaos by subcutaneous inoculation*

Animal number	Vaccine serial	Dose	Result
		cc.	
Carabao 1188	[a] S–5	25	Large flat swelling 24 hours after inoculation, sensitive, disappeared after 4 days.
Carabao 1187	[a] S–5	25	Do.
Carabao (69)	[b] S–5	25	Thin flat swelling 24 hours after inoculation, slightly sensitive, disappeared after 4 days.
Carabao (70)	[b] S–5	25	Do.
Carabao 1141	[c] S–5	25	Do.
Carabao 1145	[c] S–5	25	Do.
Carabao 1146	[d] S–5	25	Large flat swelling 24 hours after inoculation, sensitive, disappeared after 4 days.
Carabao 1149	[d] S–5	25	Do.
Carabao (62)	[a] S–6	25	Do.
Carabao (61)	[a] S–6	25	Do.
Carabao 1147	[c] S–7	25	Slight swelling 24 hours after inoculation. Disappeared after 3 days.
Carabao 1148	[c] S–7	25	Do.
Carabao 1189	[d] S–7	25	Do.
Carabao (63)	[d] S–7	25	Do.

[a] Supernatant fluid [b] Filtrate [c] Washed sediment [d] Whole vaccine

Experiment 8.—Throughout the preceding immunity tests of this vaccine in large animals a single injection of 10 cc. was consistently employed. Such a dose refers to vaccines with a concentration ranging from 250 to 300 million bacteria per cubic centimeter. The uniform protection conferred upon the vaccinated carabaos and cattle which resisted a severe test inoculation of virulent cultures, proved beyond doubt the immunizing property of the vaccine.

It was believed that the practical efficacy of the vaccine would be further enhanced if the product could be concentrated without impairing its potency. This experiment aims to determine if this is possible of accomplishment. In five consecutive serials (serials 5, 6, 7, 8 and 9) the concentration was raised from two to five-fold and the dose reduced to 5 cc. Rabbits given the full dose all survived the test inoculation while the control died. Likewise, carabaos and cattle which received the same dose and subsequently injected with virulent culture all resisted except one carabao which received a vaccine of low concentration. Table 8 shows the result of this experiment in detail.

TABLE 8.—*Tests of concentrated vaccine on rabbits and large animals*

Species and number	Vaccine serial number	Concentration per cc.	Dose	Virulent 24-hour broth culture	Result
		Millions	*cc.*		
R–49	5	750	5	½ cc. containing 12,500 bacteria.	Lived.
R–50	5	750	5	do	Do.
R–51	6	1,500	5	do	Do.
R–52	6	1,500	2½	do	Died.
R–53	7	600	5	do	Lived.
R–54	7	600	3	do	Died.
R–55	8	600	5	do	Lived.
R–56	8	600	4	do	Do.
R–57	9	400	10	do	Do.
R–58	9	400	5	do	Do.
R (7)		[a]	[a]	do	Died in 48 hours.
Carabao 1171	5	750	5	1 cc. containing 300 millions.	No reaction.
Cattle 1177	5	750	5	do	Do.
Carabao 1184	6	1,500	5	do	Do.
Cattle 1877	6	1,500	5	do	Do.
Carabao (75)	7	600	5	do	Temperature reaction, lived.
Cattle 2015	7	600	5	do	Do.
Carabao (78)	8	600	5	do	Do.
Cattle 2026	8	600	5	do	Do.
Carabao 1179	9	400	5	do	Died.
Cattle 1920	9	400	5	do	No reaction.

[a] Control

STABILITY OF THE VACCINE

In the tropics, the value of the keeping quality of a vaccine at room temperature cannot be overemphasized, especially in rural districts where a refrigerating system of any kind is usually not available. Two separate vaccines prepared in a concentration of 400 million per cubic centimeter with the buffalo and Mindoro strains were kept at room temperature. After 9 months each vaccine was tested on one cattle and one carabao giving 10 cc. dose per animal. Three out of four animals resisted a subsequent test dose of 2 cc. of a 24-hour virulent culture. Two animals presented a local and temperature reaction, but recovered within a week. Further tests on the stability of these vaccine are in progress in order to draw a more definite conclusion upon this important point.

FIELD VACCINATION

The encouraging results obtained with this phenolized vaccine on rabbits and large animals under laboratory conditions warranted giving it a field trial. With the approval of Dr. S.

Youngberg, Director of Animal Industry, vaccine was supplied to the Animal Disease Control Division for use in infected towns. In some localities the infection was severe and animals attacked usually died. In others, the severity was more moderate. On the whole, a single injection of 10 cc. subcutaneously produced the desired effect. Reports from our filed veterinarians so far confirm our results in the laboratory. At the present writing some 10,425 animals have been vaccinated in 22 infected towns distributed in 8 provinces and in no case has it become necessary to revaccinate in order to check infection.

The present vaccine being used in the field is prepared by combining the buffalo and Mindoro carabao strains in equal concentration. Before being passed, the vaccine undergoes a double potency test, one on rabbits and another on cattle and carabaos. No serial is considered satisfactory for distribution unless these conditions have been fulfilled. Under present laboratory arrangements, the carabaos and cattle that have passed the potency test for rinderpest vaccine are in turn utilized for the potency test of hemorrhagic septicemia vaccine, thereby effecting economy on this score. The vaccine as it is now dispensed is concentrated and is administered in a dose of 5 cc. subcutaneously or intramuscularly. Subcutaneous injection is much to be preferred.

DISCUSSION

While Mohler and Eichhorn and later Hardenbergh and Boerner have succeeded in preparing hemorrhagic septicemia vaccines of living attenuated organisms, the latter authors have pointed out the disadvantages of such product. First, the loss in vaccinated animals was about 1.8 per cent; second, the vaccine was capable of infecting hypersusceptible animals; third, postvaccination abscesses were not infrequent (Plate I); and fourth, the possibility of disseminating living organisms during vaccination. The one point in favor of the vaccines is the more active immunity conferred upon the vaccinated individuals. From the standpoint of practical application, however, it is obvious that aside from the higher degree of protection which it confers, the disadvantages far exceed the advantage. Considering the sporadic or enzoötic nature of hemorrhagic septicemia natural infection, a prophylactic which would check its spread would suffice. It is believed that the phenolized whole culture vaccine here described answers this requirement. Being a ster-

ile product, it is free from the objectionable features of the living attenuated vaccine.

As previously stated, one of the essential factors in the preparation of a potent vaccine is the maintenance of the stock cultures in a vigorous state. It is not enough that the organisms be strongly pathogenic; they must be highly antigenic as well. By frequent transfers through rabbits at certain determined intervals, antigenic strains will preserve such characteristics from generation to generation without deterioration. The minimal lethal dose of such a type of organism, which kills rabbits regularly in 24 to 48 hours, was found to be from 12,500 to 15,000 organisms of a 24-hour broth culture. On this basis, it was determined that the minimal lethal dose for carabaos and cattle which kills them in 48 hours was from 300 to 600 million organisms of a 24-hour broth culture or about 20 to 50 thousand times the minimal lethal dose for rabbits. Schonwerth(8) mentioned by Ford, estimates that a single hemorrhagic septicemia organism will produce infection in a susceptible animal.

In connection with the potency tests, it might be argued that the test dose of the virulent culture used in the experiment was so small as to leave little margin of safety. This is taken care of by the following safeguards: (1) Rabbits are highly susceptible to hemorrhagic septicemia organisms. (2) As Schonwerth has shown, one organism is enough to cause infection in a susceptible animal. In my own case I was able to kill rabbits with 6,000 organisms. (3) In the direct test on large animals 20,000 to 50,000 times the lethal dose in rabbits was used. This provides for the margin of safety desired.

Another factor contributory to the production of a potent vaccine is the medium in which the organisms are planted. It is believed that the broth described herein possesses the essential vitamines or hormones which these organisms require for optimal healthy growth. By the method of preparation outlined, the active hormones have apparently suffered very little change judging from the potency of the vaccine prepared from such broth.

Tuft succeeded in intradermal vaccination against typhoid and claimed to have removed the toxic after-effects of the ordinary three subcutaneous injections. The hemorrhagic septicemia intradermal vaccination described in Experiment 1 rendered the rabbits immune against a fatal dose of virulent culture. The result of subcutaneous injections of phenolized whole vaccine con-

clusively proved that it was likewise capable of protecting rabbits (Table 1). When vaccinations were made on large animals (carabaos and cattle) the results were no different and all vaccinated subjects survived the test inoculation.

Comparative tests of vaccines containing local strains against a vaccine of the buffalo strain showed that the local Mindoro strain was equally antigenic. The Batangas strain, however, was wholly inefficient. Incidentally the sugar reaction of this strain was atypical of the hemorrhagic septicemia group. It was later determined that a number of non-antigenic local strains also exhibited similar atypical behavior on the various sugars; namely, gas formation and acidity, notwithstanding that they were all pathogenic for rabbits. An effective vaccine was obtained with the combination of the Mindoro and buffalo strains. For the various tests performed in this paper vaccines containing 300 million per cc. have been used, except in the experiment on concentrated serials.

A preliminary test on the length of immunity conferred by the vaccine revealed that the vaccinated animals were still immune 28 and 36 days respectively after injection. Much of the information on this point will be obtained from the results of field vaccination. However, it seems safe to state that, if our laboratory animals resisted a severe test dose of virulent culture 36 days after vaccination, under natural infection in the field such protection might be considered sufficient to halt sporadic or enzoötic outbreaks. The success thus far obtained in the control of outbreaks with a single injection of this vaccine supports this assumption.

Toxicity tests of the different fractions of this vaccine did not reveal signs of true free exotoxin. Although the supernatant fluid and the filtrate elicited definite dermal reaction in rabbits, intravenous injections of 5 cc. of each fraction failed to cause death, or any other reaction except a certain pallor of the eye membranes and dullness of the animals for one or two days. The product of bacterial disintegration was probably responsible for such manifestations in rabbits. According to Rowland(9) the toxic principle in plague bacillus (*Pasteurella pestis*)—one of the septicemia organisms—is a nucleo-protein solution of endobacterial origin. (In his experiments he showed that his material was very toxic to rats.) Carabaos and cattle given as much as 25 cc. of each fraction subcutaneously failed

to show toxic symptoms of a generalized nature either immediately after injection or several days after. It appears that the size of the local swellings at the site of inoculation in the latter animals depended upon the concentration of disintegrated bacterial cells contained in the whole vaccine and in the supernatant fluid. The thin, flat swelling produced by the filtrate in these animals would indicate a low toxicity of this fraction. One may, therefore, consider that a broth culture of hemorrhagic septicemia organisms contains a certain amount of toxin solution indistinguishable from the greater bulk which resides in the bacterial cell (endotoxin).

Of the different routes of injection employed in the course of the experiments, the intradermal and subcutaneous methods gave the most satisfactory results in large and small animals alike. Intravenous and intramuscular inoculations of rabbits completely failed to protect them. On the other hand, intramuscular vaccination of large animals was apparently effective. In the light of these observations, it seems probable that the reason for the failure of intravenous and intramuscular vaccination to protect rabbits was due to the quick elimination of the vaccine by the animal body, thus giving the tissues no opportunity to form an adequate amount of antibodies.

Concentration of the vaccine had no apparent influence on its protective value. A dose of 5 cc. of the concentrated vaccine was fully as protective as 10 cc. of the lesser concentration. Again this would indicate that the antigenic principle depends upon the bacterial extracts and the number of organisms present in a given suspension and not upon any specific toxin. Such observation places this product under the general group of bacterial vaccines in its essential characteristics.

The keeping qualities of the vaccine at room temperature have not been extensively worked out, but judging from tests made of materials exposed to atmospheric temperature for 9 months, the potency was apparently preserved with little or no deterioration. This would mean that the vaccine could be stored successfully without refrigeration. However, ice box storage is always to be preferred.

At the present writing over 10,425 doses of vaccine have been administered in the field in various separated districts and in no case has it become necessary to revaccinate in order to check the spread of infection. This creditable record demonstrates

clearly the efficiency of this phenolized whole culture vaccine as a prophylactic in the control of hemorrhagic septicemia of carabaos and cattle. Further information from field observations will definitely settle the question as to whether or not one vaccination each year will suffice as a means of control.

CONCLUSIONS

1. A prophylactic whole culture vaccine against hemorrhagic septicemia has been presented and described.

2. Intradermal and subcutaneous injections are superior to other routes of vaccination in establishing immunity. Intravenous injections in rabbits miserably failed to favorably effect resistance or immunity.

3. Experimental rabbits and large animals resisted a test dose of virulent culture 28 and 36 days after vaccination respectively.

4. Evidence at hand would indicate that the vaccine possesses the essential attributes of living vaccines because it establishes a sufficient immunity to make it an effective prophylaxis against sporadic and enzoötic outbreaks. This is born out by the results obtained from laboratory experiments and field vaccination of 10,425 carabaos and cattle in widely separated infected districts where it was never necessary to revaccinate in order to smother the spread of infection.

5. The minimal lethal dose (M.L.D.) of the strains employed in the experiments which kills in 48 hours, has been determined quantitatively and numerically for rabbits and large animals.

6. The immunizing principle of the vaccine apparently resides in the whole culture, not in any single fraction thereof.

7. No free soluble toxin has been observed in the filtrate judging from its effect on the test animals. The dermal reactions on rabbits were probably due to a nucleoprotein solution of endo-bacterial origin of the kind described by Rowland in the toxic principle of the plague bacilli.

8. The vaccine retains its potency in a cool place at room temperature, but ice-chest storage is preferable.

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ILLUSTRATIONS

Plate I

Dalupiri carabao No. 1214. (Note the swelling 10 inches in diameter at (x) 48 hours after subcutaneous injection of ½ cc. of virulent broth culture containing 150 million bacteria. The dewlop and brisket were edematous. After a week an abscess developed at the point of inoculation which was treated surgically. This animal recovered.

Plate II

Fig. 1. Skin reaction on rabbits after intradermal injection of 0.4 cc. of supernatant: (*a*) Blanching at the point of inoculation surrounded by an area of reddening, erythema, 48 hours after injection. (*b*) Idem., 72 hours old showing beginning epidermal necrosis at the center and erythema much reduced. (*c*) Idem., 96 hours old, epidermal necrosis prominent and just slight reddening. (*d*) Idem., 1 week old, with hairless superficial scar at the point of inoculation.

Fig. 2. Skin reaction on rabbits after intradermal injection of 0.4 cc. of filtrate: (*a*) Blanching at the point of inoculation with a narrow zone of reddening 48 hours after injection. (*b*) Idem., 72 hours old, the blanched area becoming brownish, and showing superficial epidermal necrosis. (*c*) Idem., 96 hours old, the superficial epidermal necrosis nearly scaled off. (*d*) Idem., 1 week old, showing a white, hairless, superficial scar at the point of inoculation.

PLATE I. Dalugiri carabao No. 1214. Note the swelling 10 inches in diameter at (x) 48 hours after subcutaneous injection of ½ cc. of virulent brain culture containing 150 million bacteria. The dewlap and brisket were edematous. After a week an abscess developed at the point of inoculation which was treated surgically. This animal recovered.

Fig. 1

a *b* *c* *d*

Fig. 2

a *b* *c* *d*

PLATE II

THE PECTIN CONTENT OF SOME PHILIPPINE FRUITS

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INTRODUCTION

Pectins are substances present in certain fruits which when boiled with enough sugars, and some added acid, if the fruits lack sufficient fruit acids, make jelly set.

Pectin occurs largely as a pectose, an insoluble material present in the covering of the intercellular walls and middle lamellæ of unripe and some ripe, but not over-ripe fruits. During the ripening of fruits, pectose is converted into a soluble pectin by the action of enzymes. This conversion is also produced by boiling the fruit with water, the change occurring more rapidly when a weak organic acid solution like lactic acid is used.

As a considerable amount of confusion arises regarding the nomenclature of pectins, various investigators using different terms to designate the individual pectin substances, a committee was appointed at the Los Angeles Pectin Symposium (1925) to study the existing nomenclature and make recommendations for the uniform naming of pectin substances. Thus, the known pectin substances may be grouped into three classes.

(1) Proto-pectin, formerly called pectose, is the insoluble form which occurs in unripe fruits, and in most other parts of plants. This is the original pectin substance from which the soluble forms are derived.

(2) Pectin is a term used to designate the soluble pectin substance occurring naturally in the juice of ripe fruits or obtained artificially by treating proto-pectin with mild hydrolytic agents.

(3) Pectic acid is obtained by subjecting pectin to hydrolysis. Pectic acid occurs naturally in over-ripe fruits and vegetables.

Since the discovery of pectin by Braconnot in 1825, a considerable amount of investigation has been done on the chemistry of this substance. Von Fellenberg (1916) showed that pectin, on being treated with NaOH, undergoes saponification like fats, yielding methyl alcohol and the sodium salt of pectic acid,

and from this he concluded that pectin is the methyl ester of pectic acid.

According to Tutin (cited by Dore, 1926), pectin yields acetone as well as methyl alcohol upon saponification. The acetone is believed to result from its isomer, iso-propenyl alcohol, $CH_3—C\begin{matrix}OH,\\CH_2\end{matrix}$ and pectin is regarded by Tutin as probably the dimethyl-iso-propenyl ester of pectic acid. Pectin is closely related to starch and the plant gums and is usually classed as a polysaccharide. As fruit rots, the pectin is changed to pectic acid by an enzyme (pectose) a reaction which also may be produced by treating pectin in the cold with NaOH.

Carré (1925) has shown that pectin in apples reaches a maximum during the process of ripening and gradually decreases as the fruits become over-ripe. These chemical changes are clearly indicated by changes in texture, for which they are probably responsible. In unripe fruits, the union with cellulose maintains the firmness of the tissues, while in overripe or rotten fruits, the methoxyl groups are split off and the tissues are completely disintegrated.

Pectin is a reversible colloid, meaning that it can be dissolved in water, precipitated, dried and redissolved in water without producing any material change in its physical or chemical characteristics or properties.

THE USE OF PECTIN

Commercial pectin preparations in liquid and powdered forms when mixed with the right amount of sugar and some acid juices are made into all kinds of fruit jellies. Fruits which are devoid of pectin or contain an insufficient amount of this substance, can, with the use of pectin powder or syrup, be made into wholesome, appetizing, and highly nutritive jellies.

Besides its use for jelly making and similar preparations, pectin is used as an emulsifying agent in the preparation of medicines. It renders the emulsions palatable and more easily administered after having been sweetened and flavored with mint.

Pectin is also used in the preparation of mayonnaise and other salad dressings; in fruit tree spray emulsions and in insecticidal sprays; and as a glue or mucilage. Very recently pectin has been found to be a blood agglutinant in the treatment of intestinal hemorrhages.

PROPORTIONS OF PECTIN, SUGAR AND ACID NEEDED TO PREPARE A GOOD JELLY

Jameson (1925) reported that jelly standards call for jelly containing about 65 per cent total solids, most of which is sugar. The sugar can be decreased to 50 per cent and still a good jelly will result. Good jellies have been found to result when the pH of the solution is from 3.0 to 3.5. With either too high or too low hydrogen ion concentration (outside of this small pH range), either syneresis takes place or no jelly forms.

Goldthwaite (1910) made studies on the proportions of sugar, acid and quantities of invert sugar produced in making fruit juice jellies, but paid little attention to the percentage of pectin actually present.

Cruess and McNair (1916) found that with a 1 per cent solution of orange pectin, a concentration of 0.3 per cent acid is necessary to give a firm jelly. Barker (1918) found that pectin must be present in quantities of 0.5 per cent or more to give a good cider apple jelly.

Poore (1926) found that the lower limits in the finished jelly for citric acid was 0.045 per cent, for pectin 0.20 per cent, and for sucrose 37 per cent. Good jellies have been prepared by him by varying the pectin, acid and sucrose contents. The following are the percentages of varying amounts of pectin, acid, and sugar to make good jellies:

Pectin	Citric acid	Sucrose
Per cent	*Per cent*	*Per cent*
0.43	0.82	43
0.43	1.07	43
0.60	0.82	43
0.60	1.07	43
0.60	1.51	40
0.77	1.07	39.1
0.93	0.82	39.1
1.11	1.13	36.4

PECTIN CONTENT OF SOME FOREIGN FRUITS AND VEGETABLES

The pectin content of some foreign fruits and vegetables is given in the following table:

Materials	Pectin content of	
	Fresh material	Water-free basis
	Per cent	*Per cent*
Apple pomace	1.5 to 2.5	15.0 to 18.0
Lemon pulp	2.5 to 4.0	30.0 to 35.0
Orange pulp	3.5 to 5.5	30.0 to 40.0
Beet pulp	1.00	25.0 to 30.0
Carrots	0.62	7.14

Many Philippine fruits, notably the guava, santol, bignay, duhat, and others are used for jelly making. Since pectin is one of the important components in jelly-making, and is also used in many important industrial preparations it is important to determine the pectin content of some of our fruits.

MATERIALS

The following fruits have been used for the investigation:

1. Bignay (*Antidesma bunius* Spr.)
2. Calamansi (*Citrus mitis* Bo.)
3. *Magnum bonum*
4. Naranjita (*Citrus nobilis* Lo.)
5. Native Orange (*Citrus aurantium* L.)
6. Tahiti Lime (*Citrus aurantifolia* Swg.)
7. Duhat (*Eugenia cuminii* (Dru.)
8. Guava (*Psidium guajava* L.)
9. Lipoti (*Eugenia curanii* C.B.R.)
10. Mabolo (*Diospyrus discolor* Ww.)
11. Papaya (*Carica papaya* L.)
12. Santol (*Sandoricum koetjape* M.)
13. Hevi (*Spondias cytherea* Son.)
14. Tamarind (*Tamarindus indica* Linn.)

METHODS OF ANALYSIS

1. The methods adopted by the Association of Official Agricultural Chemists (1930) have been followed in the quantitative determination of pectin.

The peel and pulp were reduced to fine particles by being passed through a food chopper, and thoroughly mixed, the operation being completed as quickly as possible to prevent loss of moisture.

Seventy-five grams of the well ground and mixed sample were weighed into a 400 cc. beaker and about 200 cc. of water added. The mixture was boiled for one hour, the water lost by evaporation being replaced at frequent intervals. The solution was transferred to a one-liter volumetric flask, cooled, and diluted to the mark and filtered.

A 200 cc. aliquot of the above solution was transferred to a 400 cc. beaker and evaporated to about 25 cc. and then cooled. Two hundred cubic centimeters of 95 per cent ethyl alcohol was added with constant stirring, allowing the precipitate formed to settle before filtering on a 15 cm. filter paper, and washing the precipitate with 95 per cent alcohol. The washed precipitate

was transferred to the original beaker and then 2–5 cc. of 10 per cent sodium hydroxide solution added, diluted with sufficient water to make a total volume of 50 cc. and allowed to stand for 15 minutes, after which time 40 cc. of water and 10 cc. of HCl (1:2.5) were added and boiled for 5 minutes. The precipitate was filtered through a quantitative filter paper, and then washed with hot water until the total filtrate was about 500 cc. The precipitate and filter paper were transferred to a porcelain crucible and then dried to constant weight in an electric oven kept at 100°C. The dry residue was ignited to constant weight. The loss in weight is reported as pectin. The results of concordant duplicate determinations were taken in preparing the table of pectin content.

DISCUSSION OF RESULTS

Table No. 1, shows the pectin content of some Philippine fruits. Figures indicate that the rind of green fruits of Tahiti lime (*Citrus aurantifolia* Swg.) contains 2.63 per cent pectin as against 1.49 per cent in the juice. This compares favorably with the pectin content of lemon, which is 2.5 per cent. The yellow fruits of calamansi come next with the rind containing 1.65 per cent and the juice with 0.28 per cent pectin.

Bignay, native orange, duhat, mabolo, naranjita, santol, hevi, and guave follow in the descending order. The other fruits studied were found to contain but little pectin.

The red fruits of bignay (*Antidesma bonius* Spr.) and the ripe fruits of guava (*Psidium guajava* L.) contain a much higher amount of pectin than their corresponding white and green fruits respectively. This is expected, since pectin, according to Carré (1925), reaches the maximum during the process of ripening and gradually decreases as the fruits become over-ripe.

SUMMARY

1. Fourteen different Philippine fruits have been analyzed for their pectin content.

2. Of all the fruits analyzed, the rind of Tahiti lime was found to contain the largest amount of pectin, which was 2.63 per cent.

3. Besides Tahiti rind, bignay, native orange, duhat, mabolo, naranjita, santol, hevi, and guava were found to contain a sufficient amount of pectin.

TABLE 1.—*The pectin content of some Philippine fruits*

Name of fruit	Scientific name	Moisture	Pectin	
			Fresh sample	Moisture free sample
		Per cent	*Per cent*	*Per cent*
1. Bignay:	*Antidesma bonius* Spr.			
Red fruits		90.27	0.92	9.45
White fruits		88.37	0.52	4.98
2. Calamansi:	*Citrus mitis* Bo.			
Yellow fruits		86.58		
Juice			0.28	2.08
Rind			1.65	12.29
3. Duhat:	*Eugenia cuminii* Dru.			
Whole ripe fruits			0.85	
4. Guava:	*Psidium guajava* L.			
Ripe fruits—				
Pulp			0.39	
Skin			0.42	
Seeds and some pulp			0.63	
Green fruits—				
Pulp			0.20	
Skin			0.16	
Seeds and some pulp			0.23	
5. Hevi:	*Spondias cytherea* Son.	83.45		
Skin			0.37	2.26
Pulp			0.64	3.89
6. Lipoti:	*Eugenia curanii* C. B. R.			
Ripe fruits, whole		85.97	0.19	1.35
Green fruits, whole			0.22	
7. Mabolo:	*Diospyros discolor* Ww.			
Ripe fruits, pulp		68.71	0.83	2.65
8. *Magnum bonum* (Citrus):				
Whole green fruits		88.59		
Juice			0.03	0.26
Rind			0.59	5.17
9. Naranjita:	*Citrus nobilis* L.			
Green fruits—				
Juice			0.22	
Rind			0.83	
10. Orange, native:	*Citrus aurantium* L.			
Green fruits—				
Juice			0.12	
Rind			0.85	
11. Papaya:	*Carica papaya* L.			
Ripe fruits, pulp			0.28	
12. Santol:	*Sandoricum koetjape* M.			
Ripe whole fruits		80.01		
Pulp			0.14	0.70
Skin			0.16	0.80
Seed and some pulp			0.05	0.25
13. Tahiti lime:	*Citrus aurantifolia* Swg.			
Green fruits—				
Juice			1.49	
Rind			2.63	
14. Tamarind	*Tamarindus indica* L.	76.66	0.24	1.03

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GLANDERS WITH SPECIAL REFERENCE TO BONE LESIONS

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TWO PLATES

Veterinary literature on the subject under consideration is meager. Among earlier workers, Delafield and Prudden(1) mention glanders of the joints (osteomyelitis) occasionally observed in human beings. In animals Hutyra and Marek(2) state that the ribs and vertebrae are most frequently attacked. Sections of the affected bones reveal irregular pale yellowish cavities filled with a viscid substance. There is fibrosity of the tissues surrounding the lesion. Ossifying periostatic causes enlargement of the ribs, which become anæsthetic or insensitive. There may be accompanying pleurisy. Huidekofer(3) mentions a lame horse which when destroyed revealed a glanders abscess of the bone of a foreleg and nodules in the lungs. Moore(4) describes the pathological lesions in the affected bone as essentially a cellular infiltration of the medulla and purulent breaking down of the osseous tissue. The Journal of the American Veterinary Medical Association in its issues for the past sixteen years has been silent concerning glanders involving the bone. Likewise, *Veterinary Medicine,* a Chicago paper, records no cases. Even the *Journal of Comparative Pathology and Therapeutics* and the *Veterinary Record* lack accounts of this type of clinical glanders.

In the Philippines, Gomez and De Jesus,(5) summarizing the observations made on glanders in man and horses for the past three decades, do not mention even a single case of this nature, either as a primary or metastatic condition.

The case about to be described created conflicting diagnosis due to its unusal clinical picture. By some, it was thought to be bursattee, by others bone fistula and still others indolent ulcers. To the writer it was glanders. The intradermic mallein test, bacteriological findings and the lesions found on autopsy confirmed this diagnosis.

HISTORY

On October 26, 1931, grade pony No. 742, 3 years old, iron-grey and belonging to the Alabang Stock Farm, showed upon examination by the writer one superficial skin ulcer on the lower ramus of the right jaw. Just above the sub-maxillary region on the inner side of this jaw and slightly below the level of the external ulcer was a fistulous track three inches deep running along the inner surface of the lower jaw bone with the blind end directed upward. This condition was first noticed in October, 1930. At the time of examination there was a thick viscid, odorless, serous exudate running along the skin of the throat region and matting the hair on this part. The fistula and external ulcer had been under surgical treatment for about a year. The attending veterinarian stated that at times, there was apparent healing, but later the ulcers broke out again and the exudate continued. It was noticed that the animal was gradually losing condition although lively and fairly healthy. The writer believed it was glanders and advised testing with intradermal mallein. Before the test, however, swabs were made from the fistula for bacteriological examination and guinea pig inoculation in the Veterinary Research Laboratory.

Forty-eight hours after the intradermic test the injected eye exhibited a pronounced muco-purulent discharge and edema of the lower lid together with a catarrhal nasal secretion. The animal was dejected and broken down. The entire picture was a characteristic reaction to mallein.

Destruction was ordered and the animal was brought to the city pound for autopsy.

BACTERIOLOGICAL FINDINGS

Swabs procured from the fistula were planted on agar slopes by smearing the surface of the medium. Smears prepared from the swabs and stained with Gram's method showed straight or curbed Gram negative bacilli, presumably *Pf. mallei* mixed with other pyogenic organisms. A suspension of the mixed agar cultures inoculated into male guinea pigs produced purulent orchitis (Strauss reaction) which was slow in developing. Later the scrotal sac of the guinea pigs ruptured. Microscopic examination of stained smears from the pus material revealed Gram negative straight or curved rods. Cultures made from this pus on potato slants gave a scanty growth of Gram negative bacilli having the morhpology and appearance of *Pf. mallei*.

Guinea pigs inoculated with this pus culture also developed orchitis.

AUTOPSY

Despite available methods at hand, it is often difficult if not impossible to settle a difference of opinion in the clinical diagnosis of an obscure case. For example, under certain conditions a biopsy would suffice to clear up doubts, but in the present case, this method was inapplicable, and final diagnosis must await the autopsy findings. Although the mallein reaction was strongly positive for glanders a careful post-mortem was deemed advisable in view of the fact that this was the first case found on the premises. A résumé of the lessons observed at necropsy four days after the mallein test follows.

Appearance of the animal before destruction.—Before the mallein test, the animal was sprightly with a smooth coat, bright eyes and apparently in fairly good health. Four days after the test the violent allergic reaction which followed had so depleted the condition of the subject that the writer could hardly recognize the animal. A more positive intradermic mallein reaction could not be desired.

External lesions.—There was a partly healed ulcer on the skin of the right mandible about one inch above the inferior border of the lower ramus at its proximal third. Before the mallein test this ulcer was open, but shortly before destruction it seemed to close and finally contracted into a crescent shaped scar. A partly closed ulcer marked the open end of a fistula on the inner skin of the right mandible slightly posterior and below the scar on the opposite side of the ramus. The blind end of the tract was directed upward and slightly forward along the inner surface of the lower branch of the mandible. The pocket was three inches deep. Beyond the inflammatory reaction of the inoculated eye and the nasal discharge, no other external lesions were observable.

Internal changes.—Of the visceral organs the lungs and the liver presented the most prominent lesions. Multiple calcified nodules varying in size from a millet seed to a hazel nut were found in the parenchyma of the lungs like shots. The apical right lobe was actively congested and contained a few fresh nodules. Some were fibrotic, pale when cut, but shining under the capsule. The liver contained several minute nodules which were plainly visible to the naked eye. Upon gross examination no other parenchymatous organs were found to be involved.

CRITICAL DESCRIPTION OF LESIONS IN THE MANDIBLE

The posterior third of the lower right ramus and just one inch above the inferior border showed a crescent-shaped scar of an apparently healed ulcer (Plate I, fig. 1 [*a*]). The skin around it was thickened, indurated and adhered to the bone. When dissected from the bone, there was considerable inflammatory fibrosis below the ulcer which is typical of an infectious granuloma. The external opening of the fistula was partly healed at the edges, but the center was open (Plate I, fig. 2 [*b*]). The blind end or fundus terminated in a giant nodule the size of a chestnut just below the molars on the inner surface of the lower ramus. This nodule was partly necrosed and adherent to the bone of which it formed a part (Plate II, fig. 1 [*n*]). On this portion the bone was softened, dull-grey, spongy and pitted on pressure with a hard object (Plate II, fig. 1 [*s*]). The chain of glands, including the submaxillary, were apparently sound (Plate II, fig. 1 [*gld*]). The fistulous tract was much adhered to the inner surface of the lower ramus and when dissected from it, the inferior border of the bone appeared enlarged and exostosed (Plate II, fig. 2 [*e*], [*f*]). Transverse sections through the necrosed parts revealed a soft, dull-slate color pulp, although no active canalization was observed such as was described by Moore. Evidently, bone necrosis was not sufficiently advanced to show either disintegration or canalization. There was strong evidence, however, of impending abscess formation in the bone and were it not for the early destruction of the animal, the process would have been completed.

COMMENT

The obscure train of symptoms manifested by the case under discussion was elusive and had evoked conflicting clinical diagnosis among veterinarians who had seen the animal. Indeed, such conditions as indolent ulcers, bone fistula and bursattee were incriminated and the animal had been treated accordingly without success. It was evident that the obstinacy to antiseptic and surgical treatment and the accompanying odorless viscid, ember or greyish exudate which matted the hair had been overlooked. In the Tropics any form of cutaneous affection of the horse with this tendencp of chronicity and resistance to treatment should arouse suspicion of glanders (farcy) and the mallein test should be applied without delay. On this basis

the case pony here described, was diagnosed as glanders and later this was confirmed at post-mortem.

The scantiness of growth and the low pathogenicity to guinea pigs of the culture isolated from the exudate would indicate that we were dealing with an attenuated strain of glanders organisms. Likewise, this would explain the apparent fair health enjoyed by the animal for a year previous to the mallein test. Bearing in mind the extreme susceptibility of the equidæ to glanders infection, it is unlikely that in the present case at least, resistance alone could have modified the pathogenicity of a virulent strain of glanders bacilli.

Bacteriologically, the diagnosis was confirmed by the recovery of *Pf. mallei* from the exudate either by direct culture or from the testicles of inoculated guinea pigs (Straus reaction). The allergic reaction following the intradermic test was positive for glanders beyond question. This was substantiated by the lesions found at autopsy. Apart from pulmonary and hepatic nodules, bone nodules with necrostic periostatis and exostoses were found in the right mandible. A complete discussion bearing upon these lesions has already been given.

SUMMARY

1. An obscure case of glanders in a grade pony has been diagnosed with particular regard to the bone lesions.

2. A critical description of the pathological lesions involving the right mandible has been presented.

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ILLUSTRATIONS

Plate I

Fig. 1. External ulcer of the skin of the right mandible. (*a*) Crescent-shaped healed ulcer.

2. Internal side of the right lower ramus of the mandible showing the fistula with white edges partly healed and a dark center, the opening.

Plate II

1. Dissected right mandible showing (*n*) giant glanders nodule, (*s*) softened necrosed bone where the nodule was firmly embedded, (*gld*) chain of healthy glands including the submaxillary.

2. Inferior border of the mandible showing (*c*) opening of the fistula through the skin, (*d*) mass of necrotic subcutaneous fibrous tissue to which the giant nodule was attached, (*e*) exostosis of the inferior border of the mandible, (*f*) necrotic periostatis.

Fig. 1. External ulcer of the skin of the right mandible. (*a*) Crescent-shaped healed ulcer.

Fig. 2. Internal side of the right lower ramus of the mandible showing the fistula, (*b*) with white edges partly healed and a dark center, the opening.

PLATE I

Fig. 1. Dissected right mandible showing (*n*) giant glanders nodule, (*s*) softened necrosed bone where the nodule was firmly embedded, (*gld*) chain of healthy glands including the submaxillary.

Fig. 2. Inferior border of the mandible showing (*c*) opening of the fistula through the skin, (*d*) mass of necrotic subcutaneous fibrous tissue to which the giant nodule was attached, (*e*) exostosis of the inferior border of the mandible, (*f*) necrotic periostatis.

PLATE II

THE COMPOSITION AND MIXING OF COMMERCIAL FERTILIZERS [1]

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TWO TEXT FIGURES

Fertilizers, sometimes called manures, are substances usually added to the soil for increasing and maintaining crop production. The term manures is more generally given to such materials as farmyard and green manures like the leguminous cover crops that are plowed under the soil. Experiments have shown that these leguminous crops can increase to some extent crop productivity. The term fertilizers is usually given to those which are artificially produced, notable examples of which may be mentioned sulphate of ammonia, superphosphates, also called acid phosphate, soluble potash salts, etc.

It is now well known that crops need and remove plant food elements or nutrients from the soil and if no provision is made to replace these so-called food elements, the time will come when the production will continue to decrease progressively until further cropping no longer becomes profitable. This type of agriculture, which is called *mining,* is still practiced in many backward countries. In Table 1, Jacob and Coyle give the amount of plant food elements or nutrients removed by different crops from the soil per hectare. Later, it was found that if some portions of the crops, such as the stems and leaves, are plowed under and left to rot in the soil, or certain materials, such as farmyard manures or ashes of various kinds, are added to the soil, crop production can be slightly increased and maintained. This agricultural practice is of the *conservation type.*

The Philippines, unlike many temperate countries that are well adapted to the raising of cattle, horses, etc., lack farmyard manures. The use of leguminous crops for increasing production is not only inadequate but also not always profitable. Other

[1] Written by the author when he was a member of the Agricultural Chemistry Department, College of Agriculture, University of the Philippines.

substitutes must be sought for to take the place of these substances in order to profitably increase productivity. When materials, like artificial or commercial fertilizers such as are being used in many advanced countries are employed, we are dealing with a type of agriculture that is *permanent*. Not only is crop production maintained but the amount is increased until the limit is reached.

It has long been known that plants need plant food elements for growth and development. But while formerly only about twelve elements or nutrients were considered essential, later investigations have shown that more than this number are necessary for crop production. However, most soils contain a sufficient amount of these elements, except nitrogen, phosphorus, and potassium and sometimes calcium. These latter elements are found wanting in many soils to such an extent that crop production is more or less lessened but when provision is made to add them in the right form and amount and at the proper time, notable increases in yield are obtained.

Whereas in many temperature countries soil decomposition is slower and the leaching effect of rains less pronounced than in tropical places, the use of commercial fertilizers is usually necessary, so it becomes apparent why in the Philippines the use of commercial fertilizers is going to become a regular agricultural practice.

Ever since the epoch-making discovery of the celebrated German chemist Justus von Liebig, in 1840, that plants need mineral elements for their growth and development, many investigators have been conducting further researches as to plant nutrition, which have resulted in our better knowledge of plant nutrition and how crop production can be profitably increased.

While fertilizers have been used in other countries for a long time, their use in Philippine farms is comparatively recent. Table 2 shows the fertilizer importation into the Philippines from 1920–1930. It shows that the use of commercial fertilizers is increasing. Many firms have been established for the mixing and distribution of this article of commerce.

We now hear much of commercial fertilizers in concentrated and mixed forms. At present there is a large number of mixtures being sold under different brands. These different brands are, however, largely compounded from three important concentrates, sulphate of ammonia, superphosphates and soluble potash salts.

In order to buy commercial fertilizers cheaply and use them intelligently and economically an understanding of their uses, preparation, composition and compounding is important. This paper was therefore written to furnish this information.

FUNCTIONS OF NITROGEN, PHOSPHORIC ACID AND POTASH IN PLANT NUTRITION

Each of the important plant food elements, nitrogen, phosphoric acid and potash, plays a distinct and vital function in the growth and development of plants.

Nitrogen is important because it is a constituent of the protoplasm, influences the vegetative growth, and gives color and succulence to plants. A deficiency of nitrogen is evidenced by stunted growth and yellowing of plants. An excess, however, of this element is known to delay maturity and to decrease the disease resistance of certain plants. Unlike phosphoric acid and potash, too much nitrogen application is therefore not desirable.

Phosphoric acid is a constituent of the nucleoproteins and nucleins. It favors good root development and strengthens the straw of cereals, increases the disease resistance and hastens the maturity of the plants. It is therefore a controlling factor in the production of seeds. It is also necessary in the conversion of starch into sugar. The ash of plants has been found to contain about 40 per cent of phosphoric acid.

Potassium has been shown by many experiments to increase the disease resistance of plants. It gives turgor to plant cells and is also important for inducing the healthy development of leaves and stems. Potassium is especially abundant in young vegetative parts and is important in the formation of sugar and carbohydrates. With the help of calcium, potassium is important in the translocation of starch from the leaves where it is made, into the starch storage parts of plants, such as tubers and root crops.

While each one of these elements has its own specific functions in the growth and development of plants no one of them is able to replace the other. It is therefore necessary that all these elements be present in the proper form and amount in order to have the best effect on crop production.

PREPARATION OF COMMERCIAL FERTILIZERS

A. NITROGENOUS FERTILIZERS

Materials that are used to supply nitrogen are commonly known as nitrogen carriers or nitrogenous fertilizers. The nitroge-

nous fertilizers may be divided into two general classes, the organic and the inorganic, or mineral, class. The organic may still be further divided into (*a*) vegetable, such as the different oil residues in oil manufacture, as examples of which may be mentioned copra meal, soybean meal, kapok seed meal, etc.; (*b*) animal, mostly coming from the slaughter houses such as dried blood; tankage, consisting of refuse material in the form of bones, trimmings, hides, hoofs, horns; fish meal residues obtained in fish oil extraction, etc.; (*c*) mineral, such as guano and excrement of sea fowls, wild ducks, etc.

The most important nitrogenous fertilizers of the mineral class are sodium nitrate, calcium nitrate, calcium cyanide, artificial urea and sulphate of ammonia. Sulphate and chloride of ammonia are those most commonly sold. Sulphate of ammonia, as ordinarily sold, is a crystalline white material containing about 20½ per cent of available nitrogen. It is obtained largely from the gases that formerly were allowed to escape in the production of coke, which contain a considerable amount of ammonia gas that is allowed to bubble into sulphuric acid solution. This results in the production of a solution of ammonium sulphate from which the fertilizer is crystallized out by evaporation. This is a good example of a waste product later turning out to be an important product.

Sodium nitrate or Chile saltpeter, which used to be the world's chief supply of nitrogenous fertilizers, is obtained and exported in large quantities from Chile, Peru, and Colombia. Commercial sodium nitrate contains about 15 per cent of nitrogen. It is very soluble and readily available. Table 3 gives the composition and current quotations for nitrogenous, phosphatic and potassic fertilizers.

The residues, such as lumbang seed cake, soybean meal, kapok seed meal, etc., while containing considerable amounts of nitrogen (see Table 6) are not quick acting because the nitrogen is not present in available form but must first undergo nitrification in the soil. When used, their effects as nitrogenous fertilizers are not usually shown until long after their application. But whenever they can be obtained without much cost, they are good supplements to the more available and costly mineral nitrogenous fertilizers.

B. PHOSPHATIC FERTILIZERS

Materials which supply phosphoric acid to plants are called phosphatic fertilizers. There are two general classes, the (*a*)

natural phosphates, such as rock phosphate, bones, and guano; and (*b*) artificial or acid posphate, as it is called in the United States, or superphosphates, as it is generally known elsewhere. The natural phosphates, excepting guano, contain considerable amounts of insoluble phosphoric acid, which is not available to plants. The superphosphate is almost exclusively sold as the source or phosphatic fertilizers.

Superphosphate is manufactured from pulverized rock phosphate (containing about 30–35 per cent phosphoric acid) and the right quantity of concentrated sulphuric acid, in lead-lined tanks.

When different amounts of concentrated sulphuric acid are added to rock phosphate we get the following reactions:

1. $Ca_3(PO_4)_2$ + H_2SO_4 ⇄ $CaSO_4$ + $Ca_2H_2(PO_4)_2$
   rock phosphate; sulphuric acid; calcium sulphate; di-calcium phosphate (citrate soluble but water insoluble)

2. $Ca_3(PO_4)_2 + 2H_2SO_4 \rightleftarrows 2CaSO_4 + Ca(H_2PO_4)_2$
   mono-calcium phophate (water soluble)

3. $Ca_3(PO_4)_2 + 3H_2SO_4 \rightleftarrows 3CaSO_4 + 2H_3PO_4$
   phosphoric acid

So by allowing one, two, or three molecules of sulphuric acid we get dicalcium or citrate-soluble, mono-calcium or water soluble phosphates and phosphoric acid which is an oily and highly corrosive liquid.

In the manufacture of superphosphates, the maximum yield of water soluble or monocalcium phosphate is desired. Hence exact calculations are made on how much sulphuric acid and rock phosphate will have to be mixed in order to get the best quality superphosphates.

For a superphosphate to be good, it must contain the highest percentage of available phosphoric acid. Available phosphoric acid is the sum of the water soluble and citrate soluble phosphoric acid.

When water soluble or monocalcium phosphate is allowed to come in contact with rock phosphate or lime it is changed over to citrate soluble phosphate. This process is known as reversion and the product is known as reverted phosphate.

When superphosphates (water and citrate soluble phosphates) are applied to the soil they also come in contact with the bases

of the soil and the reverted phosphate is formed. One may wonder and ask what is then the use of going to all the trouble and expense of preparing superphosphates from rock phosphate (water insoluble) when it will finally change over to the latter. Rock phosphate contains about twice as much phosphoric acid and costs about one fourth as much as the superphosphates. The answer is that superphosphate when applied to the soil because of its great solubility will be more evenly and widely distributed throughout the field than the insoluble rock phosphate.

The superphosphates are ordinarily sold in grayish white powder form usually containing 18–20 per cent of available phosphoric acid.

When sulphuric acid is replaced by phosphoric acid, we get a more concentrated product known as double superphosphates.

$$\underset{\text{rock phosphate}}{Ca_3(PO_4)_2} + \underset{\text{phosphoric acid}}{2H_3PO_4} \rightleftarrows Ca(H_2PO_4)_2 + \underset{\text{double superphosphate}}{Ca_2H_2(PO_4)_2}$$

Prior to the introduction of water soluble potash salts, such as sulphate of potash and chloride of potash, wood ashes were used largely as sources of potassic fertilizers. Small amounts of potash may be obtained from such wastes as banana stalks, corn cob, and from some species of sea weeds and residues or press cakes from the manufacture of vegetable oils. (See Tables 6 and 7.)

The potash salts of commerce are mined in large quantities in the Stassfurt deposits located in Saxony, Germany. These mines were first mined for producing rock salt but a variety of salts were also found which at that time were considered impurities. These impurities include the chlorides and sulphates of sodium, potassium, calcium, and magnesium. Twenty years after the first borings were made, the value of potash as a fertilizer was established. Soon thereafter large quantities of potash were mined. At first the crude salts were sold but later special methods were used to produce the almost pure salts that we now obtain in the market.

The two common potash salts that are sold are muriate of potash (KCl) and sulphate of potash (K_2SO_4). Both salts contain about 50 per cent water soluble potash.

Kainit ($K_2SO_4.MgSO_4.MgCl_2.6H_2O$) is also sometimes sold as a potash fertilizer. It contains about 12 to 14 per cent potash. It is a low grade potash fertilizer. Since it contains an appreciable quantity of chlorides it is not good to use with plants

such as tobacco, potatoes, etc., that are sensitive to and injured by chlorides.

ANALYSIS OF COMMERCIAL FERTILIZERS

As has already been pointed out, nitrogen, phophoric acid and potash are the three important plant food elements which are usually bought in commercial fertilizers. In the analysis of commercial fertilizers, quantitative chemical methods are performed to determine not only the amounts but also the availability of these elements in the fertilizer matierials which contain them.

The analyses which are made of samples of fertilizers are determinations of moisture, nitrogen, available phosphoric acid, and water soluble potash.

Moisture is determined to ascertain the dryness of the materials. A high moisture content is objectionable; besides it lowers the keeping quality and value of the fertilizer. This determination is carried out by weighing a small quantity (usually 2–5 grams) of the representative sample in a shallow porcelain dish and then placing it in an oven kept at 100°C. to dry until it will no longer lose weight. The loss of weight represents moisture.

Nitrogen is determined by the well known Kjeldahl method or one of its modifications. A complete description of the methods of determining nitrogen, phosphoric acid and potash is given in the official and tentative methods of analysis of the Association of Official Agricultural Chemists.

The only water soluble nitrogenous fertilizers, such as sulphate of ammonia, sodium nitrate, etc., are to be analyzed for their nitrogen content, the usual Kjeldahl method is used. However, when other nitrogenous materials, such has leather meal, hoofs, hair, residues from oil factories, etc., are mixed with the fertilizers, the amount of available nitrogen from these substances is determined by the alkaline permanganate extraction method. The nitrogen of these materials is not in a readily available form for the use of plants and they must first undergo nitrification in the soil before their nitrogen can be changed into the available form.

For phosphoric acid, the water soluble and citrate soluble portions of the sample are determined, the sum of these two separate determinations being taken as the available phosphoric acid. As the available phosphoric acid content of the fertilizer increases and approaches the total phosphoric acid content, the

value of the material as a phosphatic fertilizer correspondingly increases. The available phosphoric acid content represents that portion of a phosphatic fertilizer that is readily available for plants' use. While rock phosphate contains about twice as much total phosphoric acid as the superphosphates, yet it costs only one-fourth as much. This is because the former contains phosphoric acid in an insoluble form.

Potash is determined from that portion of a potassic fertilizer which is water soluble. For this determination the well-known Lindo-Gladding method is used.

All these determinations require special apparatus, expensive reagents and are time consuming. They are, therefore, only well done in well equipped chemical laboratories such as are found in Universities, government institutions, or private laboratories under the supervision of reliable and competent chemists.

The results obtained by the author from the chemical analysis of several kinds of fertilizers that can be purchased in the market are given in Table 4. This table will give an idea of the different kinds of determinations usually carried out in commercial fertilizers.

Whenever purchasing commercial fertilizers, it is therefore important to know not only the total percentage of nitrogen, phosphoric acid or potash but also their amounts in available form as determined by the chemical methods described.

It is usually best to purchase fertilizer materials from large and reliable firms, for as a rule they use only the highest quality and readily available forms of ingredients in producing different kinds of mixed fertilizers.

FERTILIZER FORMULAE

In the preparation of commercial mixed fertilizers there has come into general use so called fertilizer formulae which express the proportion of nitrogen, phosphoric acid and potash in the mixture. This is also called the N-P-K formula. The proportion or ratios are expressed in figures, such as 10–6–2, 16.5–16.5–21.5, 15–15–10, etc. The first figure represents the per cent of nitrogen, the second, the per cent of phosphoric acid, and the last the per cent of potash in the fertilizer mixture. In other countries a large number of these different formulae or ratios are sold under attractive trade names. In the Philippines, more and more of these formulae are being introduced and sold to the farmers. In Table 3 may be seen the different fertilizer mixtures now

obtainable in Manila with their corresponding prices per ton of the material.

Bear has pointed that in the United States there are at present very many fertilizer formulae and more are being introduced from time to time. He believes that a method of standardization is necessary not only to eliminate the low grade fertilizer mixtures but also to reduce the number of mixed fertilizers to what will give the best results.

Plants will respond differently to different fertilizer ratios used as well as to the different rates of fertilizer application. Taking the ratio alone, it is not difficult to see that different ratios will produce different effects and only one will come close to the best requirements of the particular crop. In this country experiments along this line should be carried out, and it is hoped that this will soon be done, especially with reference to the major crops.

It is well known that when three variables are involved, such as different percentages of N, P_2O_5 and K_2O, all possible ratios of these three may be found by the use of an equilateral triangle, (as illustrated in Chart 1) each apex of which represents 100 per cent of each variable.

In Chart 1 is given an illustration of the use of an equilateral triangle for choosing any desired fertilizer ratio. This chart will be useful in plot experiments to determine the best ratio for any particular crop.

The use of this triangular method has been described fully by Schreiner and Bear and anyone desiring a more complete discussion on the subject should read these publications.

Using the figures in Table 3, and plotting them by the use of an equilateral triangle, we see in Chart 2 the location of the different fertilizer mixtures or formulae now being sold in Manila. The data in Table 3 must first be converted into simple ratios by finding the sum of the nutrients (N-P-K) and dividing each value by this sum. The quotient will give the new values of each nutrient, the new sum of the three ingredients now adding to 10. In order to make this clearer, let us take the mixture 10-6-2 reported in table 3. The sum of 10, 6 and 2 equals 18. If we divide 10, 6 and 2 separately by 18, we will get the ner ratio 5.6–3.3–1.1, the sum of which gives 10. By following this method of calculation and using the data reported in Table 3, we get new ratios which are given in Table 3a. By plotting these data (Table 3a) with the use of an equilateral

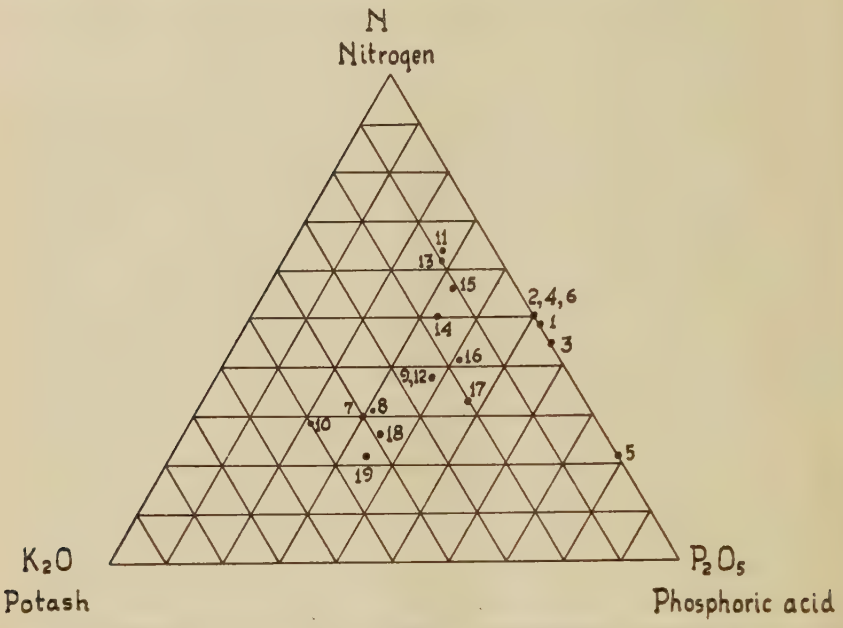

CHART 1. Fertilizer triangle showing the location of the different fertilizer mixtures now being sold in Manila.

triangle, we get the points shown in Chart 1. This chart shows the location of the different fertilizer mixtures now being sold in Manila. It is seen that a few of them are the same, such as numbers, 2, 4, and 6 and 9 and 12; the others are rather close to each other although they are sold as altogether different fertilizers suitable for certain crops.

It is hoped that investigators will, in the near future, use this triangular scheme to determine the best ratio and the rate of application of fertilizer mixtures best suited to our important crops.

MIXING COMMERCIAL FERTILIZERS

It was early pointed out in this paper that each plant food element has distinct and vital functions in the growth and development of the plants and that no one of them could replace the other.

Just as the human body requires a balanced diet for proper functioning and development, so also plants require a *balanced fertilizer*. And by a balanced fertilizer, we usually mean one which contains nitrogen, phosphoric acid and potash in the right proportion and amount.

The different fertilizer ingredients or simple fertilizers described so far furnish, as a rule, only one plant food element. In order to produce a complete or balanced fertilizer it is necessary to mix the right proportions of nitrogenous, phosphatic and potassic fertilizers. The mixing of fertilizers is now done on a commercial scale by many firms. It is a comparatively simple operation. Anybody with a little knowledge of arithmetic and the properties of the ingredients can, if he so desires, prepare any kind of mixed fertilizer.

Whenever possible, the home mixing of fertilizers should be attempted for the following reasons:

1. *Saving.*—A good deal of money can be saved by home mixing as will be shown in later calculations.

2. *Educational value.*—One learns more about fertilizers and the proportion or ratios of the plant food elements best suited to his crop.

3. *Composition.*—One is certain of the quality of his ingredients; he can not be if he uses ready mixed fertilizers that may be adulterated with slow acting or low grade materials.

4. *Fillers.*—One is not using bulky and inert fillers and also saving transportation costs incident to this item.

5. *Deterioration.*—As some changes will usually occur in long stored mixed fertilizers, one can prevent this by mixing at the time he needs them.

The mixing of the ingredients is comparatively simple and may be done on a cement, wooden or any other tight floor. From the analysis of the ingredients, their amounts are calculated and weighed. They are then spread in layers, usually the largest amount first. With the use of hand shovels, the materials are thoroughly mixed, the larger lumps being broken and screened out if necessary. The mixing should be continued until a uniformly fine product is obtained. It is then bagged and stored in a dry place until wanted.

Using a concrete-mixing machine is convenient and economical when larger amounts of home-mixed fertilizers are to be made.

The profits increase with the increase in amount of home-mixed fertilizer to be made. Where neighboring farmers can club together and form a sort of coöperative association, the home mixing will prove quite cheap.

While the mixing itself may be simple, there are certain precautions which must be observed to prevent caking and reversion of the materials and consequent losses.

Just as a pharmacist when compounding his drugs refers to a compatibility table, so a fertilizer mixer must refer to a compatibility chart. (See Chart 2.) It shows what fertilizer ingredients may or may not be mixed safely. For example, by mixing superphosphates with lime or alkali containing materials we get a reversion or transformation of the soluble (water soluble) phosphate to the insoluble phosphate. It has already been explained that superphosphate is manufactured primarily for this water soluble phosphate.

Nitrogenous fertilizers can not be mixed with lime or alkaline materials without the consequent loss of the nitrogen.

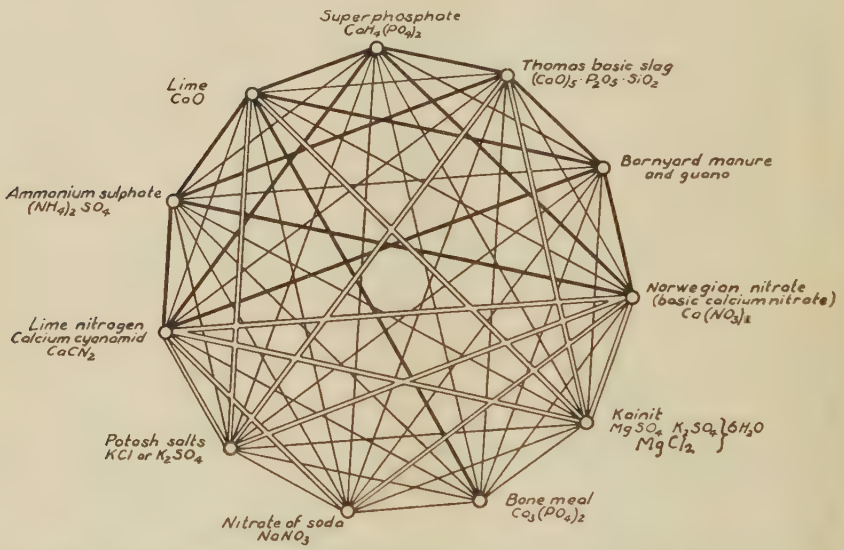

CHART 2. Showing what fertilizer materials may and may not be safely mixed. The dark lines unite materials which should never be mixed, the double lines those which should be applied immediately after mixing, and the single lines those which may be mixed at any time.

CALCULATIONS INVOLVED IN MIXING COMMERCIAL FERTILIZERS

In the preparation of different fertilizer mixtures, a number of problems may arise. A few of the more important ones with their corresponding solutions which may confront those interested on the subject are given as follows:

After having decided on the proper fertilizer mixture or ratio necessary, the next step is to compute from given analyzed fertilizer materials, the amounts of each ingredient to weigh so that after mixing we will get say a ton of the required mixture.

Using the data in Table 3, let us assume that we want to prepare a ton of a 10–6–2 mixture. The following materials are given and their cost per ton is also known:

	Per ton
Sulphate of ammonia, 20 per cent nitrogen at	₱100.00
Superphosphates, 18 per cent phosphoric acid at	45 00
Sulphate of potash, 50 per cent potash at	145.00

Let us say that we want to find out how many kilos of each of the above ingredients must be weighed and the cost of one ton of the mixture, assuming further that ₱5 is the labor expense of mixing one ton. Also we can calculate the profits of home mixing, if we base our calculation on the cost of a ton of a 10–6–2 mixture as ₱105 as given in Table 3.

SOLUTION

For a ton a 10–6–2 mixture, we need the following:

10 per cent of 1,000 kilos (1 ton) gives 100 kilos of pure nitrogen.
6 per cent of 1,000 kilos (1 ton) gives 60 kilos of pure phosphoric acid.
2 per cent of 1,000 kilos (1 ton) gives 20 kilos of pure potash.

As our ingredients are not pure with respect to these plant food substances, we can obtain the amount of sulphate of ammonia analyzing 20 per cent nitrogen needed to furnish 100 kilos of pure nitrogen by dividing 100 by 20 and multiplying by 100. This gives us $\frac{100 \times 100}{20} = 500$ kilos of sulphate of ammonia.

Similarly we need $\frac{20}{50} \times 100 = 40$ kilos of sulphate of potash and $\frac{60}{18} \times 100 = 333$ kilos of superphosphates.

According to the prices given in Table 3 the following is the cost of the fertilizer ingredients needed:

500 kilos of sulphate of ammonia at ₱0.10 per kilo	₱50.00
333 kilos of superphosphates at ₱0.045 per kilo	14.99
40 kilos of sulphate of potash at ₱0.145 per kilo	5.80
873	70.79

The total sum of the ingredients is 873 kilos. Since 1,000 kilos are needed, we must add 127 kilos of what is commonly called as a *fertilizer filler* or *make-weight*. The fillers ordinarily used are sawdust, fine earth, low grade guano, etc. Some of these fillers contain considerable percentages of N, P_2O_5 or K_2O and when

they are used as fillers they increase the analysis of the fertilizer mixture. However the N, P_2O_5 and K_2O of most fillers are usually not in as readily available forms as are found in concentrated commercial fertilizers. After adding 127 kilos of filler, we will finally get 1,000 kilos or 1 ton of the desired mixture. Now, adding ₱5 as the labor cost of mixing 1 ton we have a total cost of ₱75.79 for the home mixed 10–6–2 fertilizer. Subtracting this from ₱105, the quoted price for a 10–6–2 fertilizer, there is left a savings of ₱29.21 per ton by preparing the desired mixture in the farm.

From the foregoing calculations, it is seen to be profitable to prepare home-mixed fertilizers, and if large quantities of the fertilizers are needed the practice becomes highly recommendable.

By summarizing the above calculations into a table, we get the following:

Quantity	Ingredients and composition	Nitrogen	Phosphoric acid	Potash	Cost per kilo	Total cost
Kilos		*Kilos*	*Kilos*	*Kilos*	*Pesos*	*Pesos*
500	Sulphate of ammonia 20 per cent N	100	.....	.....	0.10	50.00
333	Superphosphates 18 per cent P_2O_5	.....	60	.....	0.045	14.99
40	Sulphate of potash 50 per cent K_2O	.....	.....	20	0.145	5.80
127	Filler	.....	.....	.....	.....	.....
1,000	Total	100	60	20	.....	70.79
	Formula	[a] 10	6	2	.....	.....
	Labor cost of mixing 1 ton	.....	.....	.....	.....	5.00
	Final cost per ton	.....	.....	.....	.....	75.79

[a] Ten (10) is obtained by dividing 100 by 1,000 and multiplying by 100.

Quotation of a 10–6–2 fertilizer	₱105.00
Savings per ton by home mixing	29.21

In Tables 3 and 7, we can obtain the following data and to simplify calculations let us take the analysis of copra meal as that reported below:

Sulphate of ammonia 20% N. at ₱100 per ton.
Copra meal 3% N, 0.50% P_2O_5 and 0.50% K_2O at ₱30 per ton.
Double superphosphates 40% P_2O_5 at ₱130 per ton.
Sulphate of potash 50% K_2O at ₱145 per ton.

Copra meal and other fertilizer fillers have been used in the preparation of mixed fertilizers. Whenever they are good as fillers they can be obtained without cost or purchased and transported cheaply. Table 7 gives the analysis of some possible fertilizer fillers which were analyzed in this laboratory.

Using these figures, a problem may come up to calculate the amount of each of the four ingredients and filler necessary for a ton of a 5–8–10 mixture, assuming that 80 per cent of the nitrogen will be furnished by sulphate of ammonia.

SOLUTION

Following the same procedure used in the solution of the first problem, we need for a ton (1,000 kilos) of a 5–8–10 mixture the following:

5 per cent of 1,000 kilos = 50 kilos pure N.
8 per cent of 1,000 kilos = 80 kilos pure P_2O_5
10 per cent of 1,000 kilos = 100 kilos pure K_2O

Since 80 per cent of the nitrogen must come from the sulphate of ammonia, then

Eighty per cent of 50 = 40 kilos of pure nitrogen to be supplied by sulphate of ammonia and

$$\frac{40 \times 100}{20} = 200 \text{ kilos of sulphate of ammonia will be needed.}$$

Since 50 kilos of pure N. are needed and 40 were furnished by the sulphate of ammonia, then 10 kilos of pure nitrogen must come from copra meal.

$$\frac{10 \times 100}{3} = 333.3 \text{ kilos of copra meal to be used.}$$ Three hundred thirty-three and three-tenths kilos of copra meal (0.50% P_2O_5 and 0.50% K_2O) will also furnish 1.7 kilos of potash and 1.7 kilos of P_2O_5. Since the formula requires 100 kilos of pure K_2O, then 98.3 kilos must come from sulphate of potash which will be

$$\frac{98.3}{50} \times 100 = 196.6 \text{ kilos of sulphate of potash.}$$ The formula also needs 80 kilos of P_2O_5. Subtracting from this the 1.7 kilos coming from copra meal we have 78.3 kilos left to be supplied by the double superphosphates, or

$$\frac{78.3}{40} \times 100 = 195.7 \text{ kilos of double superphosphates.}$$

The sum of sulphate of potash, copra meal, double superphosphates and sulphate of ammonia equals 925.6 kilos. Then we

need 74.4 kilos of filler to make exactly 1 ton of a 5–8–10 mixture.

We can make a tabulated solution of the above problem as follows:

Quantity	Ingredients and composition	Nitrogen	Phosphoric acid	Potash	Cost of ingredients
Kilos		*Kilos*	*Kilos*	*Kilos*	*Pesos*
200	Sulphate of ammonia, 20% N	40	.....	.....	20.00
333.3	Copra meal, 3% N, 0.5% P_2O_5 and 0.5% K_2O	10	1.7	1.7	10.00
195.7	Double superphosphates, 40% P_2O_5	.....	78.3	.....	25.44
196.6	Sulphate of potash, 50% K_2O	.....	.....	98.3	28.51
74.4	Filler	.....	.....	.....	.....
1,000	Total	50	80	100	83.95
	Formula	5	8	10	.....
	Cost of labor for mixing 1 ton	.....	.....	.....	5.00
	Final cost of 1 ton	.....	.....	.....	88.95
	Price of a 5–8–10 mixture	.....	.....	.....	105.00
	Savings of home mixing per ton	.....	.....	.....	16.05

When the following ingredients are available

Sulphate of ammonia, 20% N.
Fish scrap, 6% N.
Superphosphates, 18% P_2O_5
Sulphate of potash, 50% K_2O

are given, and we are asked to calculate the exact amount of each of the four ingredients without using a filler, we must proceed as follows:

5% of 1,000 = 50 kilos pure N.
8% of 1,000 = 80 kilos pure P_2O_5
10% of 1,000 = 100 kilos pure K_2O

Then we need the following:

$$\frac{80 \times 100}{18} = 444 \text{ kilos superphosphates and}$$

$$\frac{100 \times 100}{50} = 200 \text{ kilos sulphate of potash.}$$

These two gives a total of 644 kilos, leaving 356 kilos to be filled by both sulphate of ammonia and fish scrap. Since 50 kilos of pure nitrogen are required by the mixture per ton, the per cent of nitrogen when the two nitrogenous carriers are mixed will be $\frac{50}{356} \times 100$ or 14 per cent.

Since the two nitrogen carriers are sulphate of ammonia with 20 per cent N and fish scrap with 6 per cent N, and we need to

prepare a mixture of the two to give 14 per cent N, we can use the rectangular method of calculation as follows:

Place the higher value, 20, on the upper left hand corner and the lower value, 6, on the lower left hand corner of the rectangle and the desired value at the intersection of the two diagonals. The desired value subtracted from the higher value (20) gives 6, which is placed on the lower right hand corner of the rectangle. The lower value (6) subtracted from the desired value (14) gives 8 which is placed on the upper right hand corner of the rectangle. The new figures denote that we must mix 8 parts of sulphate of ammonia and 6 parts of fish scrap in order to obtain a mixture to analyze 14 per cent nitrogen. Since 8, 6 represent parts by weight of the two ingredients, we can compute the weights of sulphate of ammonia and fish scrap needed to mix in order to give a mixture weighing 356 kilos and analyzing 14 per cent nitrogen by the following calculation:

$$356 \times \frac{8}{14} = 203.4 \text{ kilos of sulphate of ammonia, and}$$

$$356 \times \frac{6}{14} = 152.6 \text{ kilos of fish scrap.}$$

Tabulating the above calculations we get:

Quantity	Ingredients and composition	Nitrogen	Phosphoric acid	Potash
Kilos		*Kilos*	*Kilos*	*Kilos*
203.4	Sulphate of ammonia, 20% N	41	.....	.....
152.6	Fish scrap, 6% N	9	.....	.....
444	Superphosphates, 18% P_2O_5	.....	80	.....
200	Sulphate of potash, 50% K_2O	.....	.....	100
1,000.0	Total	50	80	100
	Formula	5	8	10

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TABLE 1.—*Showing the amount of important plant food elements removed from the soil by some important crops per hectare*

Crops	N	P_2O_5	K_2O
	Kilos	*Kilos*	*Kilos*
Bananas	95	25	305
Cacao	50	23	148
Coconuts	65	30	95
Corn	97	55	113
Coffee	25	5	30
Oranges	63	28	73
Pineapples	125	33	310
Rice	60	18	63
Sugar cane	85	60	198
Tobacco	103	13	108

TABLE 2.—*Value of commercial fertilizers imported into the Philippines from 1920 to 1930* [a]

Year	Quantitity	Value
	Kilograms	*Pesos* [b]
1920	1,810,780	325,156
1921	1,868,138	184,875
1922	3,046,468	401,040
1923	9,391,964	1,223,906
1924	31,743,632	4,320,123
1925	31,152,766	3,976,247
1926	18,251,017	1,936,388
1927	34,554,122	3,821,211
1928	36,036,299	3,686,367
1929	53,269,067	5,763,248
1930	52,571,588	4,722,343

[a] From a private communication by the Director, Bureau of Commerce and Industry, Manila, August 21, 1931.

[b] One peso equals fifty cents, U. S. currency.

TABLE 3.—*The composition and quotation of commercial fertilizers sold in Manila* [1]

Fertilizer material	Nitrogen (N)	Phosphoric acid (P_2O_5)	Potash (K_2O)	Price per ton
	Per cent	*Per cent*	*Per cent*	*Pesos*
Chloride of ammonia	24	.....	.....	150
Sulphate of ammonia	20–20.6	.....	.....	95–105
Nitrate of soda	16	.....	.....	140
Superphosphate single	.....	18–20	.....	45–50
Superphosphate double	.....	39–45	.....	95–135
Sulphate of potash	.....	.....	48–50	140–145
Copra cake	.....	.....	.....	20–35
Peanut cake	.....	.....	.....	70
Lumbang press cake	.....	.....	.....	20
Guano	.....	.....	.....	20
Mixture 48–50	48	50	.....	.....
Mixture 20–20	20	20	.....	120–160
Mixture 16.5–20	16.5	20	.....	150
Mixture 15–15	15	15	.....	150
Mixture 13–48	13	48	.....	110–150
Mixture 10–10	10	10	.....	112
Mixture 16.5–16.5–21.5	16.5	16.5	21.5	170–178
Mixture 15.5–15.5–19	15.5	15.5	19	178
Mixture 15–15–10	15	15	10	140–170
Mixture 15–11–26.5	15	11	26.5	170
Mixture 14– 6–2	14	6	2	124
Mixture 13–13–8	13	13	8	112
Mixture 13– 6–2	13	6	2	120
Mixture 12– 8–4	12	8	4	100
Mixture 10– 6–2	10	6	2	105–120
Mixture 9– 9–4	9	9	4	105
Mixture 8– 9–7.5	8	9	7.5	100
Mixture 6– 8–9	6	8	9	105
Mixture 5– 8–10	5	8	10	105

[1] From current quotations in Sugar News, August, 1931, and from private letters from the Director of the Bureau of Commerce and Industry and fertilizer firms of Manila, August, 1931.

TABLE 3A.—*Translation of the fertilizer mixtures given in table 3 to simple ratios giving 10 as total sum of ingredients*

Fertilizer mixture	Equivalent ratio which gives total sum of ingredients of 10
1. 48 –50	4.9–5.1
2. 20 –20	5.0–5
3. 16.5–20	4.5–5.5
4. 15 –15	5 –5
5. 13 –48	2.1–7.9
6. 10 –10	5 –5
7. 16.5–16.5–21.5	3.0–3.0–4.0
8. 15.5–15.5–19	3.1–3.1–3.8
9. 15 –15 –10	3.8–3.8–2.4
10. 15 –11 –26.5	2.9–2.1–5.0
11. 14 – 6 – 2	6.4–2.7–0.9
12. 13 –13 – 8	3.8–3.8–2.4
13. 13 – 6 2	6.2–2.8–1.0
14. 12 – 8 – 4	5.0–3.3–1.7
15. 10 – 6 – 2	5.6–3.3–1.1
16. 9 – 9 – 4	4.1–4.1–1.8
17. 8 – 9 – 7.5	3.3–3.7–3.0
18. 6 – 8 – 9	2.6–3.5–3.9
19. 5 – 8 –10	2.2–3.5–4.3

TABLE 4.—*Analyses of commercial fertilizers used in the College of Agriculture, University of the Philippines*

Sample	College number	Moisture	Nitrogen (N)	Phosphoric acid (P_2O_5)			Potash (K_2O)
				Total	Available	Insoluble	
I. Nitrogenous:		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1. Ammonium sulphate	1	1.46	19.73	0.20	0.14	0.06	1.08
2. Ammonium sulphate	6	0.64	19.65	0.19	0.11	0.08	1.22
3. Ammonium sulphate	1A	1.30	20.19	0.13	0.09	0.04	1.42
4. Calcium cyanamide	3	9.75	8.18	0.42	0.27	0.15	0.46
5. Guano	18	15.54	7.44	0.12	0.09	0.03	6.24
6. Sodium nitrate	9	2 43	12.27	0.26	0.07	0.19	.....
7. Tankage	15	14.37	13.10	2.03	0.46	1.57	1.60
II. Phosporic.							
1. Superphosphate	2	21.42	0.84	31.13	29.98	1.15	0.23
2 Superphosphate	4	23.42	0 86	15.53	13.52	2.01	0.43
3. Mineral superphosphate	11A	13.27	0.07	19.67	19.54	0.13	2.59
4. Double superphosphate	13	13.75	0.02	33.52	21.86	11.66	3.80
5. Reverted phosphate	11	1.89	0.31	14.33	0.37	13.86	1.22
6. Reverted superphosphate	17	16.22	3.15	11.55	1.01	10.54	1.69
7 Reverted superphosphate	19	2.65	.....	22.75	0.16	22.59	1.09
III. Potassic:							
1. Potassium sulphate mixed with earth	7	11.85	0.12	0.17	0.14	0.03	4.01
2. Potassium sulphate	10	5.92	0.42	3.51	0.04	3.47	19.00
3. Potassium sulphate	12	2.55	0.12	0.82	0.23	0.57	12.86
4. Potassium sulphate	16	3.84	1.23	0.13	0.07	0.06	43.75
5. Wood ashes	14	24.65	0.16	2.29	0.29	2.00	6.77

TABLE 5.—*Analysis of some Philippine bat guanos*

Source	Moisture	Nitrogen (N)	Phosphoric acid (P_2O_5)		Potash (K_2O)
			Total	Available	
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Batangas	.....	8.5	4.28	.....	.....
Bulacan	.....	1.31	6.73	.....	.....
Capiz	.....	2.13	4.07	.....	.....
Cavite	9.20	8.81	5.32	3.86	.....
Guimaras Island	.....	1.43	12.50	7.10	1.53
Laguna	.....	10.57	2.11	2.04	1.56
Marinduque	15.38	3.52	7.06	.....	0.92
Mindoro	9.30	2.26	7.31	.....	0.67
Rizal	9.54	2.01	7.68	.....	.....
Tayabas	45.40	0.22	6.05	.....	0.02

TABLE 6.—*Comparison of the fertilization value of some Philippine seed cakes with that of cottonseed meal*

Sample	Moisture	Nitrogen	Phosphoric acid		Potash
			Total	Available	
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Castor, *Ricinus communis* Linn.	8.64	4.80	1.75	1.55	1.04
Copra, *Cocos nucifera* Linn.		3.04	0.56	0.51	2.71
Cottonseed, *Gossypium* spp.	7.50	6.37	2.65	2.45	1.58
Kapok, *Ceiba pentandra* (Linn.) Gaertn.	13.67	5.21	2.80	2.74	6.76
Lumbang banucalag, *Aleuritis trisperma* Blanco	8.48	3.97	2.29	2.18	1.31
Lumbang bato, *Aleuritis moluccana* (Linn.) Willd	8.19	6.46	3.36	3.28	1.50
Palomaria, *Callophyllum inophyllum* Linn.	6.25	2.48	1.01	0.96	1.00
Tuba or physic nut, *Jatropha curcas* Linn.	9.91	2.14	1.33	1.25	2.42

TABLE 7.—*Analysis of some possible Philippine fertilizer fillers* [a]

Sample	Nitrogen (N)	Phosphoric acid (P_2O_5)		Potash (K_2O)
		Total	Available	
	Per cent	*Per cent*	*Per cent*	*Per cent*
Banana stalk (ash)		2.37	1.41	21.58
Bat guano	10.57	2.11	2.04	1.56
Carabao manure	1.63	1.07	0.91	1.46
Chicken manure	3.53	1.92	1.56	2.47
Copra meal	3.04	0.56	0.51	2.71
Corn cob (ash)		4.58	4.01	10.53
Duck guano	0.45	1.77	1.15	1.50
Fish scraps:				
Arius spp., catfish (Eng.), *kanduli* (Tag.)	6.43	7.05	4.95	1.18
Chanos chanos Forsk., milkfish (Eng.), *bañgos* (Tag.)	7.27	8.87	7.21	1.52
Clarias magur, mudfish (Eng.), *hito* (Tag.)	8.45	10.02	7.29	1.05
Glossogobius spp., Goby (Eng.), *bia* (Tag.)	7.82	5.42	4.78	1.10
Ophicephalus striatus Bloch., mudfish (Eng.), *dalag* (Tag.)	8.64	11.72	9.26	1.08
Pristopoma hasta Bloch., Grunt (Eng.), *ayungin* (Tag.)	6.01	5.15	3.23	2.46
Horse manure	0.60	1.12	0.98	1.59
Kapok seed cake	3.67	1.08	0.92	0.77
Leather scrap	7.59	0.83	0.53	34.47
Sea weeds:				
Aghardiella spp., *gulaman dagat* (Tag.)	1.90	1.69	1.04	7.96
Eichornia crassipes (Mart.) Water hyacinth	1.33	1.88	0.88	9.57
Entercmorpha spp., *Digman* (Tag.)	1.61	0.92	0.61	4.33
Hydrilla verticilata (Roxb.) Royle, *inata* (Tag.)	1.74	0.76	0.56	4.24
Limnanthemun indicum (Linn.) Griseb. *Butingubal* (Tag.)	1.17	0.96	0.71	3.58
Ottelis ismodes (Linn.) Pers., *Espada* (Tag.)	1.42	0.87	0.50	3.56
Pristia stratiotes (Linn.) Solms, *Kiapo* (Tag.)	1.61	0.93	0.53	3.57
Vallisneria gigantea Graebu., *Sintasintasan* (Tag.)	1.10	1.72	0.63	5.23
Tobacco stems	2.53	0.68	0.44	0.77
Waste from cigar and cigarette factories	2.87	1.16	1.02	3.45
Waste from copra making (ash of coconut shell)		1.94	1.59	4.38
Waste from lumber mills (ash of sawdust)		1.69	1.43	6.99
Waste from rice mills (ash of rice hulls)		0.32	0.31	5.97
Waste from sugar mills (ash of bagasse)		3.59	2.57	0.70
Waste from slaughter houses	11.65	0.57	0.37	0.67
Waste from manufacture of soybean cake	6.53	0.25	0.12	2.58

[a] Elazegui (1929)